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PROGRESS ON THE SIMPLON TUNNEL during July is reported in the "Schweizerische Bauzeitung" as follows: The north heading advanced 515 ft., the south heading 718 ft., a total of 1,233 ft. This brings the total length of heading to 41,259 ft., of which 24,843 ft. is in the north end, 16,416 ft. in the south end. The total working force during July amounted to 3,229 men, of whom 2,223 were employed within the tunnel, 1,006 outside. The geological conditions remained constant in the north heading; the average daily advance in this end was 16.9 ft. The south heading was in slaty magnesian limestone, interleaved with sheets and veins of anhydrite; the average daily advance was 23.4 ft. The temperature of the rock was measured in the north heading at Km. 7.461, and was found to be 127° F.

THE ELECTRICAL EQUIPMENT FOR THE MERSEY tunnel railway at Liverpool, England, has been nearly completed at the Westinghouse Works at East Pittsburg, Pa., and the last of the generators and engines will shortly be on their way across the ocean. The generators are of 1,200 K-W. capacity direct connected to 1,500 HP. vertical cross-compound Westinghouse Corliss engines. Four of these units will be installed to furnish current for the railway and two 200 K-W. units will furnish current for lighting the tunnel and stations. The Mersey tunnel railway, which was completed in 1886, is about 4½ miles in length, of which about two miles constitute the tunnel under the river and the approaches. The approaches are on a grade of about 3% and to handle the trains on these grades a powerful motor equipment is to be provided. Each train will consist of five 60-ft. cars, the first and last cars each being equipped with four 100-HP. Westinghouse motors governed by the Westinghouse electro-pneumatic system of train control. While the English bull-head rails are used for the track, T-rails, 60 ft. in length and weighing 100 lbs. per yd. are to be used for the conductor rail and also for a fourth rail carrying the return current. Both these conductor rails are supported on stoneware insulators. In this way all risk of stray return currents causing electrolysis will be avoided.

SUBWAYS FOR PIPES AND WIRES in connection with the rapid transit railway in New York city continue to be advocated by public-spirited citizens and some of the city officials. A word in their behalf has just been spoken by Mr. Jacob A. Cantor, President of Manhattan Borough, in his last quarterly report, while a recent number of the "Merchants' Association Review" contains reports on the same subject by Mr. Jas. C. Bayles.

MUNICIPAL OWNERSHIP OF GAS and electric lighting plants at Holyoke, Mass., seems to be approaching, although progress is very slow. The project began to assume definite shape on Dec. 15, 1896, when a resolution was introduced in the board of aldermen which resulted in the appointment of a committee to investigate the subject. On Dec. 6, 1897, the aldermen passed a resolution in favor of buying the lighting plants of the Holyoke Water Power Co. On Dec. 14, 1897, the people voted, 2,540 to 1,735, to buy the works. This was followed by a proposition to make a ten-year lighting contract with the company instead, but the opposition was so great that the project was abandoned. On July 17, 1900, a special election on reconsidering the vote to purchase was held, resulting in a vote of 1,926 for and 2,136 against, thus defeating reconsideration by a majority of 210. The small majority was ascribed to the fact that the day of the election was hot and many people absent from the city. In the course of time a commission was appointed to fix the price the city should pay for the plant. The commission made an award a few weeks ago of $708,790, divided as follows: Gas works, $376,066; electric lighting plant, $329,356; bonus for 16 mill powers, $56,356. The award was made as of Jan. 1, 1898, the date immediately following the popular vote to buy the property, but inasmuch as the company has had the revenues since that date, no interest charges are added. The full report of the commissioners, subject to final amendments, was published in the Holyoke "Transcript" for Aug. 6, 1902. The value of franchises was excluded, and allowances for depreciation were made, but the "going" value of the plant was taken into account. None of these details are given, and the prices stated are declared to be the "fair market value" of the various divisions of the property.

MUNICIPAL OWNERSHIP OF AN ELECTRIC LIGHTing plant at New Orleans is provided for by an ordinance just passed by the city council accepting the bid of Mr. Herbert A. Bullard, of Cincinnati. The reported contract price is $1,369,000. There is talk of a veto by the Mayor, but as the bid was accepted by a vote of 11 to 4 it is thought that the veto would be overridden.

ELECTRIC PUMPING PLANTS FOR IRRIGATION in the lower reaches of the King's River drainage area, in California, have been proposed by Mr. J. B. Lippincott, M. Am. Soc. C. E., Resident Hydrographer of the U. S. Geological Survey, Los Angeles, Cal. He suggests an 1,800-HP. hydro-electric generating station in the mountains, with a 45-mile transmission line to the lower valley, where branch lines would connect with stations for pumping the seepage water already once used for irrigation.

A PROTEST AGAINST A PROPOSED ELECTRIC railway from Naples to Mt. Vesusius has been made by the science department of the University of Naples. The railway line is intended to accommodate the large traffic of tourists visiting the crater. There is at present a cable railway for this purpose. The University authorities claimed that an electric railway as close to the observatory of the University as the one proposed would affect the seismic and magnetic observations so as to render them valueless.

CIVIL SERVICE EXAMINATIONS will be held by the New York Municipal Civil Service Commission for the following positions: Sept. 15, architectural draftsman, salary, first grade, $750, second grade, $1,050; Sept. 19, topographical draftsman, maximum salary, $1,350; Sept. 26, chainman or rodman, salary third grade, $1,050, fourth grade, $1,200. Full particulars may be secured from S. William Briscoe, Secretary Municipal Civil Service Commission, New York city.

CIVIL SERVICE EXAMINATIONS will be held in Albany, N.Y., on Sept. 20, for the following positions: Architectural draftsman, salary, $3 to $5 per day; deputy mine inspector, salary, $1,200; assistant civil engineer, salary, $5 per day; leveler, salary, $4 per day; rodman, salary, $3.50 per day; bridge draftsman, salary, $5 per day; junior bridge draftsman, salary, $3 to $4 per day; engineering draftsman, salary, $4 to $5 per day. Applications must be filed in the office of the commission before Sept. 15. For further particulars address Chief Examiner, State Civil Service Commission, Albany, N. Y.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision on the New York Central & Hudson River R. R. near Schenectady, N. Y., on Aug. 20. A freight train broke in two and the rear half later ran into the forward section. Four persons were killed in the wreck. Four fatal wrecks besides the preceding make the week's record of railroad casualties an unusually bad one. In a butting collision on the Southern Ry. near Georgetown, Ind., on Aug. 24, three trainmen were killed outright and several others dangerously injured. A line of cars ran away down a grade and met an opposing heavy freight train at a trestle; both engines and many cars went into the valley below. The other three fatal accidents, each claiming one victim, were all of them simple butting collisions, the causes not being noted in the news dispatches.

THE BOILER OF A LOCOMOTIVE EXPLODED on the Chicago & Alton Ry. near Mexico, Mo., on Aug. 23. One man was killed and five dangerously hurt.

SEVERAL SERIOUS ELECTRIC RAILWAY ACCIdents occurred during the week past. On Aug. 19, a car on the Jerome Ave. line of the Union Ry. Co., New York city, jumped the track while running down a long grade at a very high speed, near midnight. One person was killed by the wreck, and a number of others were badly injured.——A butting collision on the Bay Shore Terminal Ry., near Norfolk, Va., on Aug. 24, caused the death of probably half a dozen people. An outbound and an inbound car on a single-track line were ordered to pass at a siding; the outbound car ran by, and the collision came a quarter of a mile beyond. The two cars were partially telescoped. The motorman who is supposed to be responsible for the disaster was among the killed.

AN EXPLOSION OF PULP DIGESTERS in Wilmington, Del. caused the death of at least ten workmen and the injury of several others, on Aug. 20. The digesters were two of a set of ten in the Delaware Pulp Mills belonging to the Jessup & Moore Paper Co. They exploded without warning, wrecking the building in which they were located and other buildings nearby.

A PERMANENT ACCIDENT-PREVENTION EXPOSItion is being established at Charlottenburg, near Berlin, by the German Department of the Interior, and will soon be opened. The intention is to bring to the knowledge of all concerned the newest and best means and appliances for protection against accidents—referring here chiefly to those that menace the rank and file of industrial workers. Space will be assigned, free of charge, to employers, workingmen's organizations, inventors, etc., who may wish to exhibit such devices, and free electric power will also be furnished where it is desired to show them in operation. In connection with the exposition there will be public lectures on subjects such as accident prevention, workshop hygiene, housing questions, etc.

THE WATER SUPPLY OF CHICAGO is now in such an extremely foul condition as to be decidedly dangerous, and the Health Commissioner has issued warnings against the use of lake water unless it has been either boiled or else filtered in clean and efficient filters. When the Drainage Canal was opened it was quite generally assumed that trouble from pollution of the lake would be at an end, but in an article on the intercepting sewer system of Chicago (Eng. News, April 21, 1898), it was explained that a number of sewers discharge directly into the lake, which source of pollution still continues, and is not affected by the elimination of the Chicago River as a source of pollution. To supplement the river improvement, intercepting sewers are to be built near the lake front, connecting with large sewers discharging into the south branch of the river. Work on the intercepting system, however, has been seriously delayed by controversies with contractors and other troubles, and the time for their completion is still indefinite. The present conditions are so serious, especially in view of the recent rapid spread of typhoid fever, that the Board of Education proposes to shut off the drinking fountains in and near the public schools, and to establish a plant for boiling the water, which would be stored in galvanized iron tanks. Artesian wells are also proposed to furnish a permanent supply of pure water. The typhoid fever epidemic is not due entirely to the water supply, but partly to the milk supply distributed from dirty basement dairies and groceries, the milk being not only dirty, but dosed with water and formaldehyde, as shown by recent investigations of the Health Department.

GOVERNMENT INVESTIGATIONS of stream pollution and of the qualities of natural waters in general have been instituted by the Division of Hydrography of the U. S. Geological Survey. The work will embrace the sanitary inspection of streams, turbidity and color measurements, and chemical and bacterial analyses. The cooperation of workers in various fields is desired, particularly in the physical and analytical sections. To secure uniformity in results, the department has issued two bulletins setting forth standard methods of making and reporting analyses, and describing handy apparatus for the color and turbidity determinations (see Eng. News, May 15 and July 17, 1902). These circulars can be obtained by addressing the department at Washington. The work outlined above, the department states, "is in the hands of Mr. M. O. Leighton, who is at present engaged in an investigation of the rivers of the central western States."

CONCRETE AND EXPANDED METAL SEWERS at Harrisburg, Pa., are proposed, and bids for the same are to be received on Sept. 3. There will be about 1½ miles each, of 5-ft. and 4-ft. sewer. Bids are also to be received on seven inverted siphons on connections with existing sewers, 40 manholes, 14 flap gates, and a cast-iron outfall sewer. Mr. A. C. Stamm is Secretary of the Board of Public Works, and Mr. Jas. H. Fuertes, M. Am. Soc. C. E., 140 Nassau St., New York city, is Engineer for these and other improvements at Harrisburg.

A ROLLING MILL ENGINE OF 6,000 HP.

A very large and powerful steam engine has recently been completed by the Filer & Stowell Co., of Milwaukee, Wis., for the new rolling mill of the Republic Iron & Steel Co. at Youngstown, O. It is of the Corliss cross-compound type, with cylinders 44 × 60 ins. and 82 × 60 ins., and is rated at 6,000 HP. when running at 65 revolutions per minute and taking steam at 140 lbs. pressure. The engine was designed by the builders, and we are indebted to them for drawings, photographs and other information.

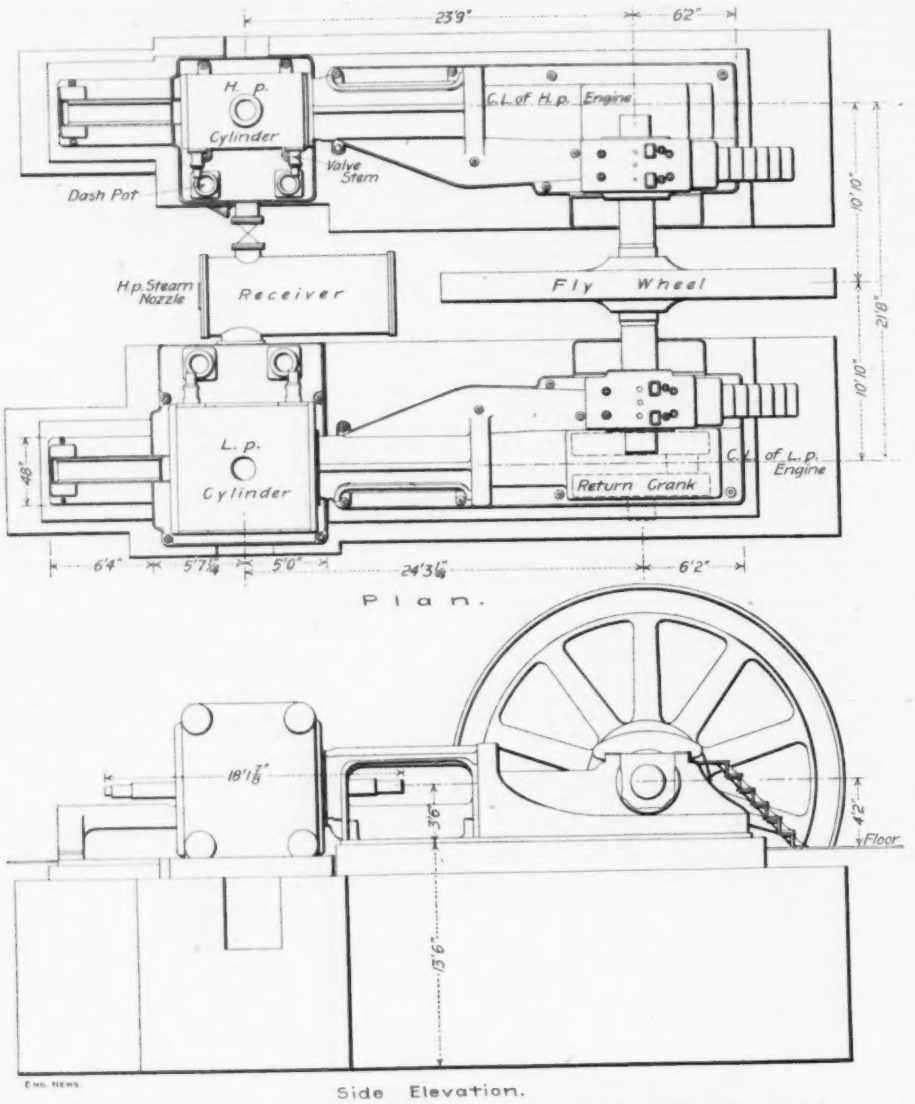


FIG. 1. GENERAL PLAN AND ELEVATION OF 6,000-HP. STEAM ENGINE FOR ROLLING MILL: REPUBLIC IRON & STEEL CO., YOUNGSTOWN, O.
The Filer & Stowell Co., Milwaukee, Wis., Builders.

The elevation and plan in Fig. 1 show the general design and arrangement of the engine. The frame, with main bearing and guides, is formed in one great casting, 26 ft. 2 ins. long, and weighing about 45 tons. No legs or pedestals are used, but the entire frame forms a flat bed-plate with a continuous bearing on the masonry foundation, a curved pocket, or recess, allowing for the downward path of the crank.

Fig. 2 is a section through the low-pressure engine, showing the position of the valve chambers and the arrangement of crosshead and tail rod. There is no overhead steam pipe between the cylinders, the steam entering below the low-pressure cylinder and passing up through a belt passage to the steam valves on top of the cylinder. The exhaust passage is underneath the cylinder, connecting directly with the exhaust valve chambers. The piston rods are of forged steel, 9 and 11 ins. diameter. The front end is screwed into the heel of the crosshead, the heel being split and fitted with bolts, so that it can be clamped tightly upon the threaded rod, and there is also the usual jam nut at the back of the crosshead. The crosshead is of cast steel, fitted with independent steel shoes at top and bottom, the faces of the shoes being turned to fit the curved form of the guides, which are bored out to a radius of 38 ins. The shoes are faced with 7-16-in. of babbit metal. The crosshead pin is 12 × 16¼ ins., made with a taper fit in the walls of the crosshead, and having a wedge and screw adjustment for taking up the wear. In order to carry the weight of the piston and prevent grooving or scoring of the cylinder, tail rods are used, formed in one piece with the piston rods, the pistons being secured by a collar in front and a nut at the rear. The tail rod is fitted with a crosshead sliding on flat guides supported by the cylinder casting and a pedestal. This crosshead is of semi-steel, with a slipper of the same material faced with babbit; the slipper is adjustable, so that any wear can be taken up, and the cylinder wall thus relieved of undue pressure.

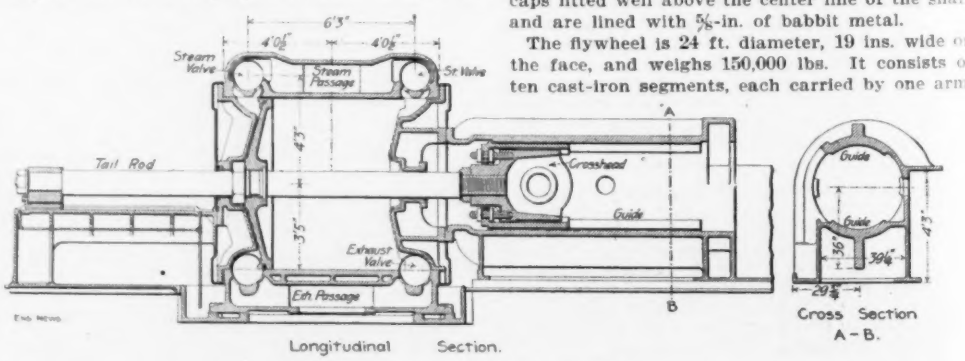


FIG. 2. LOW PRESSURE ENGINE.

The 44-in. high-pressure piston is of cast steel, of double-plate box section, 11 ins. wide on the face. The 82-in. low-pressure piston, Fig. 3, is also of cast steel, but is a single dished plate so as to reduce the weight. It is fitted with a cast-steel follower to hold in place the single cast-iron packing ring. This ring is 1¼ ins. wide, and is made in halves, being set out by 24 curved steel springs, as shown in the plan. The follower is secured to the piston by 30 stud bolts having collars to ensure their all being brought to a uniform bearing when screwed up. The width of face is 6 ins. The pistons are babbited to prevent scoring of the cylinder, and the consequent necessity for reboring. Both the pistons have a single packing ring and two babbit rings let into dovetailed grooves in the face; the wide rings of the high-pressure piston have a double dovetail, while the narrower rings of the low-pressure piston have a single dovetail, as shown. The cylinders are lubricated by an oil pump worked from one of the T-cranks of the valve gear, the oil being delivered through pipes to the valves at each end of the cylinder.

The connecting rods are 14 ft. long, c. to c. of bearings, with the crosshead end formed solid and slotted out for the brasses, while the crank end has a bolted cap. Fig. 4 shows the connecting rod of the low-pressure engine, which is 9 to 12 ins. diameter in the body. The brasses in the solid end are fitted to the 12-in. crosshead pin; they are adjusted by a wedge and secured by set screws. The crank end has brasses fitted to a 23-in. crank pin, and the cap is secured by two 6-in. bolts, made to a driving fit in the head and cap, and fitted with hexagonal nuts. Set screws are screwed through the cap into the bolt to prevent any slacking of the bolt, and U-shaped adjusting shims are placed between the head and cap of the rod. The high-pressure rod is practically identical in construction, but of slightly smaller dimensions, with a 12-in. crosshead pin and 14-in. crank pin.

The shaft is of double hammered iron, 20 ft. 6 ins. long, 25 × 43½ ins. at the bearings, 22 ins. diameter at the cranks, and 26 ins. diameter at the wheel fit, with two keyways for each crank and two for the flywheel hub. The crank arms are of the fantail counterweighted pattern, shrunk upon the shaft and keyed. The high-pressure crank is overhung, but the low-pressure crank pin carries a return crank with the hollow stub shaft for the clutch connecting with the main shaft of the rolling mill. A view of the shaft, fitted up with the cranks and flywheel hub, and loaded for shipment, is shown in Fig. 5, while the details of shaft, crank arms and crank pins are shown in Fig. 6. The arms are of cast steel, and the crank pin of forged steel, the pins being 14 × 14 ins. and 23 × 14 ins. for the high and low pressure cranks, respectively. The 25-in. main bearings have the caps fitted well above the center line of the shaft and are lined with ⅝-in. of babbit metal.

The flywheel is 24 ft. diameter, 19 ins. wide on the face, and weighs 150,000 lbs. It consists of ten cast-iron segments, each carried by one arm, the inner ends of the arms being fitted between the cheeks of a hub casting and bolted through these cheeks. The segments are put together with cast-steel links of "dumb-bell" pattern, fitting recesses in the sides of the rim; these links are 5 × 4¾ ins. section in the body and 26 ins

ing. They are put in place hot, drawing the segments tightly together by shrinkage in cooling, after which the recesses are filled with cast metal. In Fig. 7 the flywheel is shown erected in the shop to have the face turned by the lathe shown at the left. The arms are bolted to the hub, but

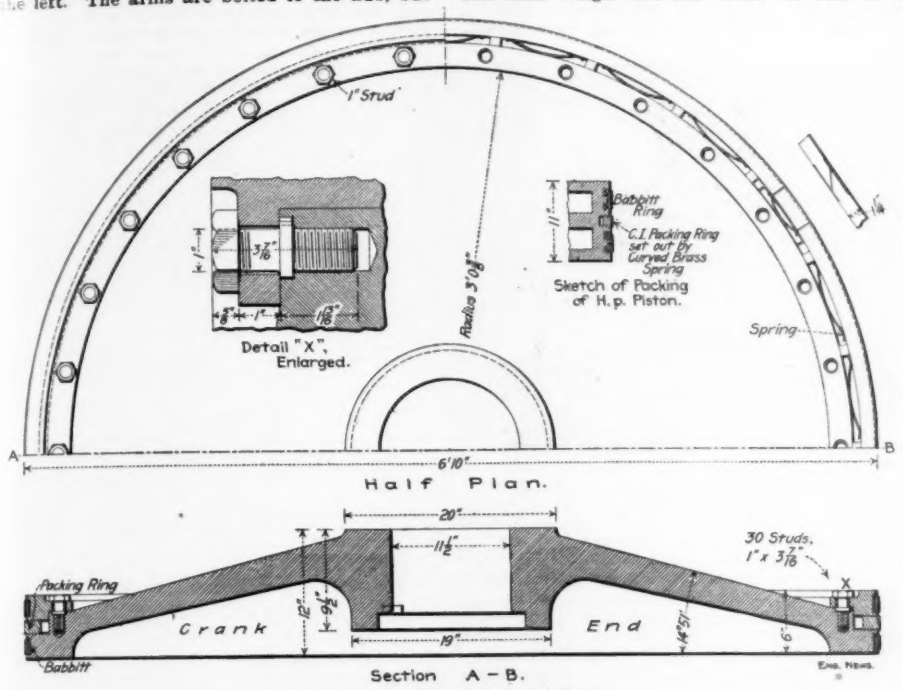


FIG. 3. LOW PRESSURE PISTON.

bolts are used temporarily in the rim, instead of the links, as the wheel has to be taken apart again for shipment. The hub is of cast iron, and consists of two separate disks, weighing together nearly 9 tons. They are 40 ins. diameter at the shaft and 7 ft. 3½ ins. over the cheeks or flanges, which are 3 to 4½ ins. thick and 10 ins. apart. The length over the shaft bearing is 3 ft., and only the outer 13 ins. of each piece grips the shaft, the inner part being counterbored to a larger diameter than the shaft.

The valves are of the Corliss type, and work in chambers formed in the main cylinder castings; these chambers have double ports, designed for high speed service and to reduce the travel of the valve. The length of the high-pressure valves is 4 ft. 6 ins. over the faces, and their form is shown in Fig. 8. The steam and exhaust valves on the high-pressure side are 7½ ins. diameter, while those on the low-pressure side are 14 ins. diameter.

The valve gear is designed for high speed, and presents some features of particular interest. That of the high-pressure side is shown in Fig. 9. The arrangement is the same on both sides, except in regard to the lengths of levers and certain other dimensions. There are two eccentrics on each side, 44 ins. diameter, 7 ins. wide on the face and bored out to 25 ins. The throw is 10⅛ ins. for the steam and 11½ ins. for the exhaust on the high-pressure side, and 13⅛ and 13¼ ins. on the low-pressure side. The steam rod on the high-pressure side is 13 ft. 9⅛ ins. long, and operates a vertical 24-in. rocking lever, on the same axis with which is a 36-in. lever carrying the hook rod. This latter is connected to the lever or crank of the front steam valve, and another rod connects cranks on the stems of the two steam valves so that they are worked in unison. The governor rod also runs to the front steam valve. The exhaust eccentric rod drives an 18-in. rocking lever, with a 27-in. lever on the same axis; from this the exhaust hook rod runs to the upper arm of a three-armed wrist lever or T-crank (taking the place of a wrist plate), while the two side arms carry rods connecting with cranks on the exhaust valve stems. The steam valves are controlled by dash-pots in the usual way, the dash rods being engaged and released by the valve stem levers by means of a trip gear; the lap of these trips is adjustable while the engine is running.

The governor is smaller and run at higher speeds than is usual on Corliss engines. It is of the enclosed two-ball type, the balls being attached to top and bottom radius rods and being enclosed in a chamber which forms the weight. The balls weigh 18.6 lbs. each. A belt on the engine shaft runs on a double-flanged pulley on a shaft enclosed in a bonnet and driving the governor shaft by a bevel gear. The rising and falling of the governor sleeve, as the speed of the governor varies, shifts the cut-off rod. There is no hunting of the governor, even under sudden vibrations in load. It is designed to maintain any given speed between 62 and 68 revolutions per minute, and will regulate the speed to within 1% above or below the normal speed, and it is said that on many engines the regulation is often much closer than this. A double-flanged idler pulley running on the governor belt is carried by an arm on a movable lug, which normally forms the footstep of the governor sleeve. Should the governor belt break, the idler pulley would drop, causing the footstep to be withdrawn, so that, as the governor stops (for want of power), the sleeve would drop further than usual and operate as a safety trip rod, which will put the cut-off valves in such position that the engine takes no steam. This apparatus is permanently in condition for work, and does not require any attention in stopping or starting the engine. The governor is placed on the high-pressure side and operates the cut-off on both cylinders by means of a cross shaft. Ordinarily the cut-offs of the two cylinders are operated alike, but a hand adjustment on the cross shaft enables the low-pressure cut-off to be varied temporarily.

The engine is fitted with both a standard 14-in. stop valve and a 14-in. quick-closing stop valve, the latter being of peculiar design, for use in reversing the engine. The valve is of I-section, with the stem horizontal and the heads curved to rotate against ports in a chamber inside the exterior casing of the valve. A slight turn of the valve closes these ports. The valve stem extends through the chamber and is fitted with a bevel wheel driven by a larger bevel wheel on the hand wheel shaft, so that the valve is operated very quickly. A counterweight on the valve stem prevents any lost motion. This arrangement is shown in Fig. 10.

The main steam pipe is 14 ins. diameter, and enters the top of the high-pressure cylinder casting, midway between the steam valves. An exhaust pipe, 16 ins. diameter, leads to the receiver, which is a horizontal cylinder, 12 ft. long and 4 ft. 6 ins. diameter, placed between the cylinders. From this a pipe, 26 ins. diameter, leads to the steam passage of the low-pressure cylinder, and the exhaust pipe from this cylinder is 30 ins. diameter, leading to a Flier & Stowell surface condenser, which maintains an average vacuum of 26 ins. Steam at 140 lbs. pressure will be supplied by Stirling water-tube boilers. The engine will run a mill for rolling structural shapes.

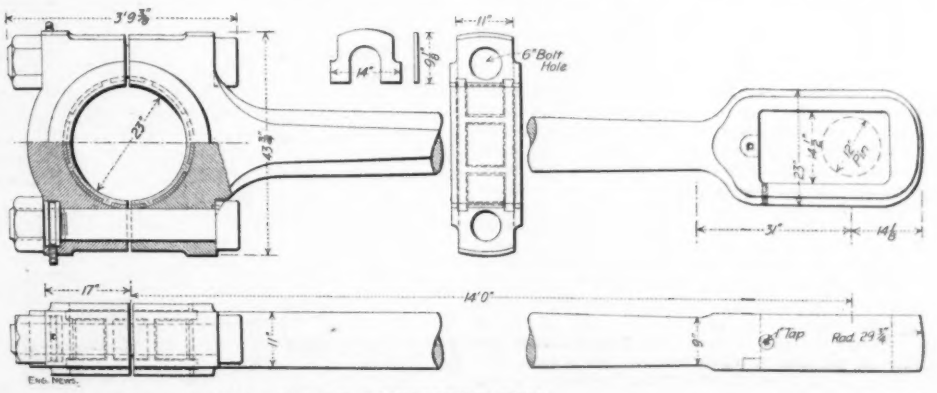


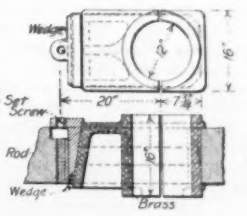
FIG. 4. LOW PRESSURE CONNECTING ROD.

SOME POINTS IN THE CONSTRUCTION OF THE CONTINUOUS SEWAGE FILTER.*

By F. Wallis Stoddart.†

The main principle underlying this type of filter may be stated to be the preservation of the interstices of the filter as air-spaces in the freest possible communication with the external atmosphere. There is evidence of some weight to show that the ventilating currents essential for providing the necessary supply of oxygen follow closely the course of the liquid applied to the filter, and that the vertical continuity of the air-spaces is of more importance than the horizontal; from which it follows that there must be no hindrance to the access of air to the surface and base of the filter. Experience proves, indeed, that whilst no appreciable difference can be detected in practice between a filter wholly open at the sides and one so enclosed as to leave the base only in communication with the air, complete closure of the sides and base of the filter (with the exception, of course, of an outlet for the effluent) results in a total cessation of its oxidizing action. A primary consideration, therefore, is that the filter body, especially as regards its base, must not be enclosed within impermeable walls.

Passing to the construction of the filter body itself, it is necessary to point out that there are three chief contributing factors to the ultimate closure of the interstices of the filter, and therefore to the cessation of its activity after a longer or shorter time. These factors are, in order of importance: (1) The disintegration of the medium; (2) the deposition of sewage solids, and (3) coating of the medium with organic growth. Of these, by far the most serious is the first, because the resulting fine material is quite permanent and resists biological destruction. However carefully the filtering medium is prepared, fine gritty dust appears at the outlets of the filter, at first in considerable quantity, later (but for



*Slightly condensed from a recent paper before the Incorporated Association of Municipal and County Engineers.

†City Analyst, Bristol, England.

a prolonged period) in smaller traces. Means of ensuring its removal must therefore be provided. Sewage solids in the very finely divided condition in which alone they should be allowed to pass on to a filter are largely amenable to microbic action, and, indeed, are not recognizable in the effluent from a filter in good condition; by themselves they will not do more than temporarily depress the action of a well-constructed filter, but, of course, they will materially add to the mischief caused after itself. In any case one layer of 6-in. material on the floor is advisable.

Reference has already been made to the question of a retaining wall, and to the necessity of freely piercing any such wall at its base. On grounds of economy alone, it would seem advisable to dispense with masonry altogether. Furnace clinker, which up to the present has given the best results of all the numerous materials tried, forms an excellently coherent bed, the outer surface of which may be almost or quite vertical without danger. The appearance is by no means bad, and the least possible obstacle is offered to aeration.

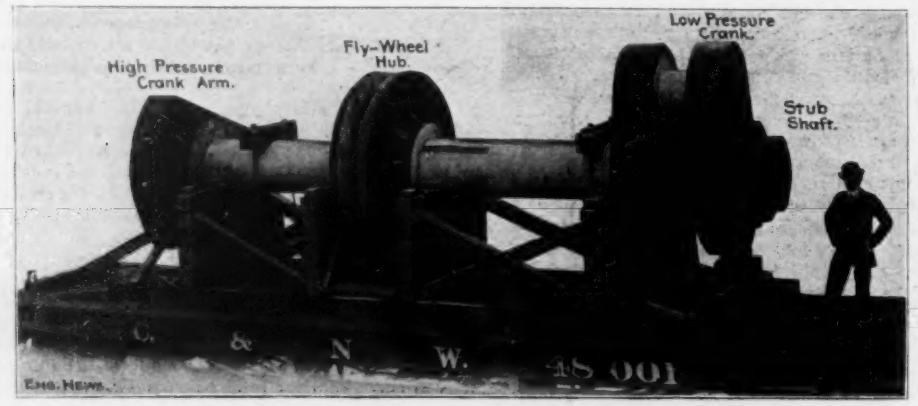


FIG. 5. SHAFT AND CRANKS, FOR 6,000-HP. ENGINE.

by the retention of the stable clinker débris. This third factor, organic growth, is of two kinds, according to its position. That in the interior of the filter, at a greater depth than about 6 ins., rapidly assumes a permanent condition, and can therefore be satisfactorily allowed for. Upon the surface of the filter, however, as is well known, a more or less continuous layer of fungoid matter frequently forms, varying in extent and thickness from time to time, and may interfere with the proper feeding of the filter. It is probable that the best remedy for this condition is a superficial layer of very large clinker, so that the growth is unable to extend from particle to particle. It has been suggested that the formation of this growth is promoted by the continuous dropping of tank effluent upon the same spots, and is obviated by the use of the intermittent appliances of short period known as rotating sprinklers. This suggestion, for which there are no scientific grounds, is completely disproved by the experience at Bristol, where of two continuous filters, and one filter fitted with an intermittent sprinkler, all being supplied with sewage of similar domestic character, the last alone has developed a "blanket" growth of a troublesome kind. Now, these materials, and especially the clinker dust, are, under the influence of the continuous flow, constantly making their way to the base of the filter, and if arrested there will, more and more rapidly as they accumulate, destroy the action of the filter. Means must be provided for their escape. The first to be considered is the design of the floor. The form originally suggested—namely, a plain surface sloping towards the nearest exterior—has proved in practice to be the most effective, whilst it also lends itself to the conditions of ventilation noted above. The even sweep of the liquid over the plain surface seems to keep it clear of obstructions, as shown by the uniform discharge of effluent at all points in the circumference of the filter. The introduction of channels, especially if associated with inclined surfaces not in the direction of flow, is found to check the current and to encourage the local deposition of solids.

Next in importance is the grade of medium, the selection of which is necessarily a matter of debate, since two directly antagonistic considerations have to be weighed. The capacity for work of the continuous filter is in direct proportion to the extent of surface offered by the medium, and that surface is obviously greater the smaller the particles of which that medium is composed. The most active filter, therefore, will be that in which the grade of material is finest, provided the interstices are kept open. The latter proviso demands a certain coarseness of medium in order to prevent choking by the agencies already referred to. Now, a long and tedious series of experiments has shown that coarse sand becomes ineffective in a day or two, ¼-in. clinker in three months, ¾-in. clinker in seven months, and so on. On the other hand, the 3-in. material ultimately adopted was deliberately chosen as being entirely free from tendency to choke, and this is so valuable a feature as to render it worth while to sacrifice a certain amount of additional temporary efficiency to secure it. It is, however, quite open to others to maintain that it may be possible by means of an improved material, and perhaps at the expenditure of some trouble in cleansing, to keep a finer filter open, and obtain increased efficiency. It is probably the desire to retain the use of a fine medium that has led to the introduction from time to time of various systems of aerating pipes into the body of the filter. This is a perfectly useless proceeding. If the medium at the termination of the pipe is impervious, the latter is useless; if the interstices are open, aeration will look after itself.

In reference to the method of feeding the filter, it will only be necessary to state here that the most satisfactory will be that which in the most economical manner combines the most complete comminution of the liquid with the least expenditure of force and the least disengagement of odor, due importance being also given to the conservation of fall. If, as is undoubtedly the case, the maximum amount of work is to be obtained from a given volume of filter body by uniformly maintaining the proper proportions of liquid and air, there can be no advantage, but, on the contrary, a loss of efficiency, in arranging for alternating periods of rest and overdosing. The distributing apparatus, therefore, should work perfectly uniformly over long periods of time, and should, if possible, be practically independent of supervision. These features are combined in the distributor, which

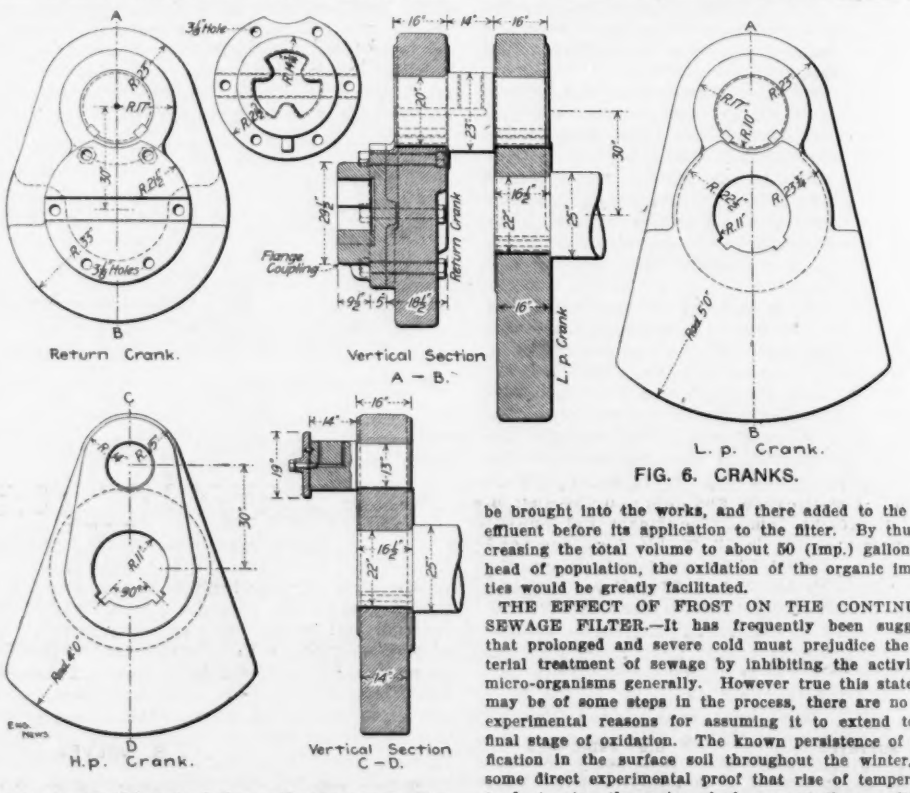


FIG. 6. CRANKS.

forms an essential part of the continuous sewage filter. This apparatus consists of a number of narrow gutters inserted at both ends into specially designed channels, which both feed and supply them. The whole of this system must be laid perfectly level, no fall whatever in the supply channels being required. The escape of liquid from the distributors is so free and unimpeded that with the maximum flow along the channels no measurable rise in level is apparent. The system of channels may be directly connected with the outlet of the tank, the floors being flush with the invert of the latter; if circumstances necessitate a length of channel between tank and filter, a baffle chamber should be interposed to [illegible] the flow. In several instances the supply channels have been laid with a distinct fall, and the effect has been, of course, to feed only the most distant distributors, or even those irregularly.*

There are two matters connected with the use [illegible] than the construction of this filter which may be [illegible] fully mentioned here. It is surprisingly rare to [illegible] sewage works with an efficient means of gaging the [illegible] and the trifling display made by the drops of liquid falling from the points of the distributor is so deceptive [illegible] these filters are commonly, though unintentionally, [illegible] overworked. It should be remembered that one drop [illegible] second from each point is equivalent to a flow of [illegible] (Imp.) gallons per hour per sq. yd., the full dose for

TABLE I.—Horfield Continuous Sewage Filter. Relation of Temperature to Nitrification.

Date.	Minimum temperature of air, Fahr.	Nitric nitrogen per 100,000
Feb. 7	24	
" 8	26	
" 9	25	
" 10	21	Greater than [illegible]
" 11	18	
" 12	18	
" 13	15	
" 14	18	2.90
" *15	19	2.75
" 16	20.5	..
" 17	18	3.10
" 18	21	2.75
" 19	32	..
" 20	32	..

*TABLE II.—Analysis of Filter Effluent, Feb. 15. (Parts per 100,000.)

Saline ammonia	9.1
Albuminoid ammonia	0.33
Nitric nitrogen	2.75
Oxygen absorbed in four hours at 80° F.	1.51
Chlorine as chloride	11.70

3-ft. filter, and that, assuming that only one-fourth of the points are working, each should deliver only four drops per second. It is almost impossible without direct measurement to persuade the inexperienced observer that the total flow is so considerable. Secondly, it has been pointed out elsewhere that a dilute tank effluent is more amenable to treatment than a strong one, because the additional water provides means of applying more dissolved oxygen to the oxidizable impurities. In many localities there must be a considerable quantity of more or less polluted and useless subsoil water, the removal of which from the neighborhood of dwellings would add to their healthfulness, and which at small expense could be brought into the works, and there added to the tank effluent before its application to the filter. By thus increasing the total volume to about 50 (Imp.) gallons per head of population, the oxidation of the organic impurities would be greatly facilitated.

THE EFFECT OF FROST ON THE CONTINUOUS SEWAGE FILTER.—It has frequently been suggested that prolonged and severe cold must prejudice the bacterial treatment of sewage by inhibiting the activity of micro-organisms generally. However true this statement may be of some steps in the process, there are no good experimental reasons for assuming it to extend to the final stage of oxidation. The known persistence of nitrification in the surface soil throughout the winter, and some direct experimental proof that rise of temperature tends to stay the series of changes at the penultimate stage of nitrosification, are sufficient to throw doubt upon the cessation of biological oxidation at temperatures short of actual freezing; whilst the largely increased solvent power of water for oxygen at low temperatures is, of course, a favorable factor. However, there are me-

*For a more detailed description of the distributors, see the abstract of Professor Kinnicutt's paper, elsewhere in this issue.—Ed.

chemical as well as biological matters to be taken into consideration, and the prolonged frost in February of this year afforded a welcome opportunity of ascertaining whether the continuous sewage filter was affected as a whole by a sustained low temperature. The frost commenced with the month of February, but became severe on the 7th and continued so until the 20th. The observations taken were not so complete as would have been the case if it had been possible to foresee the spell of cold weather, but Tables I. and II. give such results as were noted, and suffice to show that during the whole of the time nitrification was fully maintained, whilst the incubator test proved the effluent to be uniformly imputrescible.

The lowest temperature noted for the effluent from the filter was 35° F. Considerable freezing occurred in the distributors, especially at nights, and the outlets and lip of the filter were thickly coated with ice. The action of the filter, however, as a whole, was entirely unimpaired, and it appears unlikely that the cold in this climate will ever be sufficient to cause any interruption in working.

ABSTRACT OF DISCUSSION.

Mr. E. J. Silcock, of Leeds, thought that a more perfect aeration could be secured by building filters with perforated bottoms. Mr. Stoddart gave a rate of treatment of 2,670,000 (U. S.) gallons per acre, but the speaker had never seen a filter only 3 ft. in depth working at that rate. Mr. Stoddart had told him that the filter in question cost from $2.43 to $4.86 per sq. yd. of area ($11,761 to $23,522 per acre), according to the size. So high a cost could only be justified by superior results, but if Mr. Stoddart could guarantee the high rate of treatment just mentioned there would be no quarrel about price. One speaker expressed disappointment at the effluent from the Stoddart filter seen that morning, and another did not consider any effluent he had seen from a continuous filter fit to go into a stream without further treatment. In conclusion, Mr. Stoddart said the average chemical purification effected by his filter was 70% on the tank effluent; also that the effluent from any continuous filter contained suspended solids, or else the filter was not open enough for aeration. He preferred turning the effluent into a catchpit for moving the suspended matter, rather than land treatment, though the effect of the latter on crops was very good.

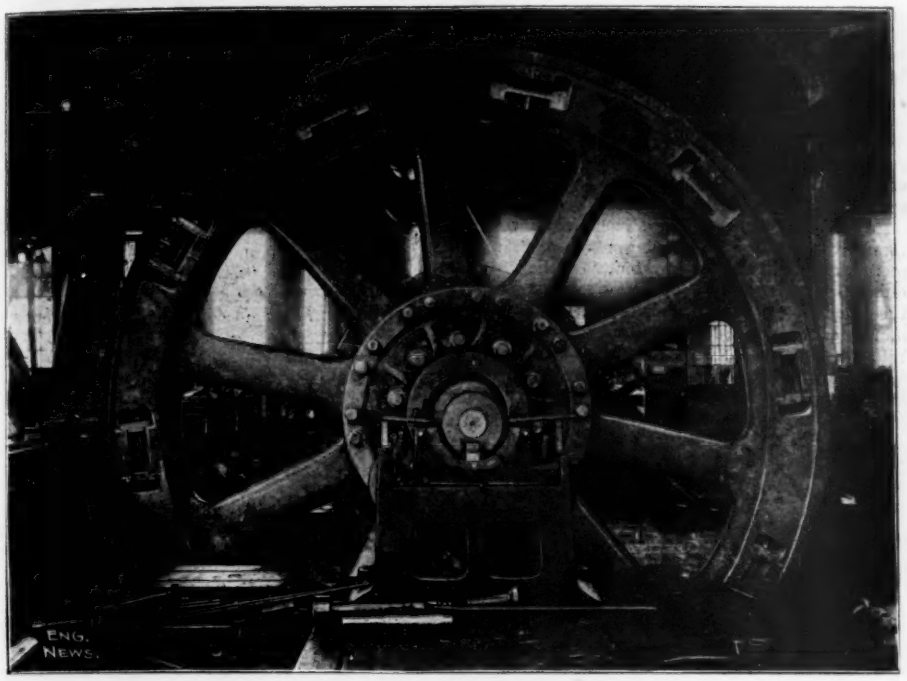


FIG. 7. FLYWHEEL FOR 6,000-HP. ENGINE; ERECTED AT THE BUILDERS' SHOPS.

A BRIEF DISCUSSION OF THE LAW OF BOUNDARY SURVEYS.*

By William E. Kern.†

A surveyor may enhance his reputation for piety, by being able to cite from the Bible, Deut. xxvii-17 and xix-14; Job xxiv-2; Prov. xxii-28 and xxiii-10, the verses mentioned referring to the sinfulness of removing land marks and the penalty therefor. Josephus has something to say on the same subject, and in his first volume of "Antiquities of the Jews," Chap. II., he intimates that the first murderer was also the first surveyor. In the 12th book of the "Aenid," Virgil recites an unusual use of a monument. The esteem of the ancients is shown by their provision of a special deity, Terminus, to preside over boundary matters; all land marks of stone being regarded as monuments to his godship.

So much for ancient history. The modern surveyor is often called upon to decide boundary disputes, where the best results would flow from a union of his efforts with those of a counsellor at law. In view of this condition and the many questions arising in the practice of a surveyor, some systematic knowledge of the subject on his part would seem desirable.

Several works upon surveying contain a number of syllabi of cases involving boundary disputes. These syllabi are condensed statements of the law applicable to a particular combination of circumstances; and have a limited utility for the purpose for which they are inserted in such text books. All laymen must be cautioned against making a general application of an abstract statement of law, as determined in some special case. To illustrate this, the following is quoted from a text book on surveying: "Seventy acres lying and being in the southwest corner of a section is a good description, and the land will be in a square. W. v. R. 2 Ham. (Ohio) 327." This is sufficient reference for a lawyer, as he would look up all the facts; but for a surveyor's enlightenment it should be explained that the description read "Seventy acres lying and being in the southwest corner of," a certain section, etc., "of the lands sold at Steubenville," and nothing further. The piece in question was part of a larger lot, and had never been marked; nor was there anything to indicate the intention as to its shape. The court disagreed with the views on both sides and held it must be surveyed as a square.

The term "boundary" is used in two senses, and may be defined as: A series of lines forming the perimeter of a specific tract of land; or, an object, parcel of land, or body of water contiguous to a specific tract of land. "Land" in legal parlance usually means a portion of the earth's surface, whether dry or covered with water. Every tract of land with which we may be called upon to deal, can be considered as having at some prior time formed part of a larger tract. Incident to the severance was the creation of a new boundary along the line of division. Every boundary in dispute may be conceived as having had such an origin. After its inception, however, neighbors on either side may, by friendly agreements between each other; or by long continued hostile encroachments by one, with neglect to assert rights by the other; or by other acts; affect the legal status of the line so as to alter its original position.

The data for determining the legal status of a boundary may be divided into two classes: (1) Circumstances connected with the severance from a parent tract at the time the line in question first became a boundary, and (2) conduct of neighbors on either side of the line, which may affect their relative status thereto.

EXTENT OF GRANT.

The first class above referred to may be designated as Extent of Grant. In discussing this subdivision, it is almost superfluous to say that the rules stated may be limited in their application in specific cases by the principles falling under the second class. In locating a boundary as determined by extent of grant, we must seek the intention of the parties to the primal conveyance.

Let us suppose that A, being the owner of a large plot of ground, divides it into two portions by a line X Y running north and south, and sells all east of X Y to B, and subsequently all on the west to M. B then sells to C, the latter to D, and D to E; M conveys to N. At a time when N is owning on one side and E on the other, it becomes necessary to define the line X Y. This must be based upon the description used in A to B, it being the one which created the line X Y. No conveyance in the chain of A to N can affect the rights acquired by E through the conveyance of A to B. The intermediate deeds should be examined, however, as they frequently throw light upon the original intention, as for example: If M took in 1821, N in 1860, B in 1820, C in 1840, D in 1860, and E in 1880, the monuments called for in 1820 may be gone in 1900, but a surveyor in 1820 might have found vestiges and restored them, or created new ones in correct positions; and another surveyor in 1860, finding the marks of 1820, may have made an accurate mathematical description and set two or more imperishable monuments.

It may be urged that the original deed cannot be found, or is too indefinite to be of any service. The attempt, however, ought always be made; if it fails we must do the next best thing. In a recent case the mesne conveyances of a plot within the limits of a large city differed about 100 ft. in frontage on a street. An examination of the original deed disclosed a call for the edge of a fast land along the side of a swamp; a city plan, showing topography, fixed the position of the water line and solved the problem.

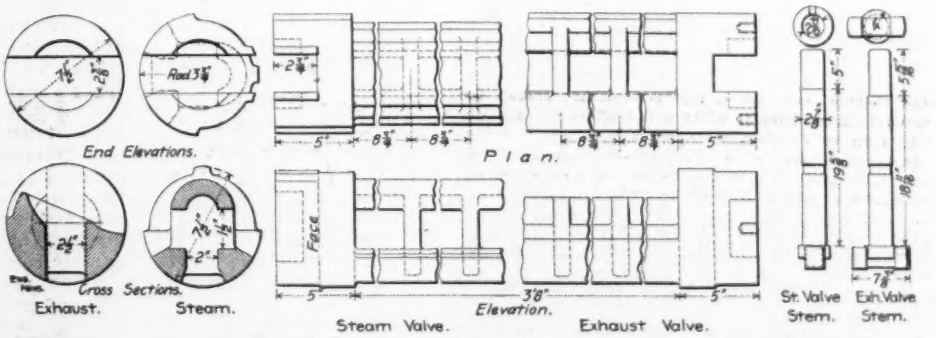


FIG. 8. VALVES FOR HIGH-PRESSURE CYLINDER.

*Copyright, 1902, by Wm. E. Kern.
†Attorney at Law and Civil Engineer, 3325 N. Park Ave., Philadelphia, Pa.

The intention of the parties is generally to be gathered from the description used in the instrument of conveyance. Description we will define as a statement designed to identify a specific tract of land. Every specific tract of land is included between lines of definite length, making equally definite angles with each other and with the meridian, and containing a definite area; and any angle point may be conceived as located at a definite distance and direction from some well-known and fixed point. Some specific tracts are marked at angle points or elsewhere by natural or artificial monuments; some are known by particular or distinguishing names. A complete description would contain all of these elements so far as they exist.

MONUMENTS.

Monuments are objects established or used to indicate the boundary of a specific tract of land. They may be natural or artificial, the distinction being too obvious to require definition. Under this head are included varieties of land, as swamps, meadows, forests, pasture, etc.; bodies of water and water courses; hillocks, cliffs, trees, rocks, buildings, walls, fences; stones, stakes, pits, etc.

Ambiguity in a description may arise from conflict between elements of a different sort, or between those of the same sort. Monuments may disagree with the mathematical description, or

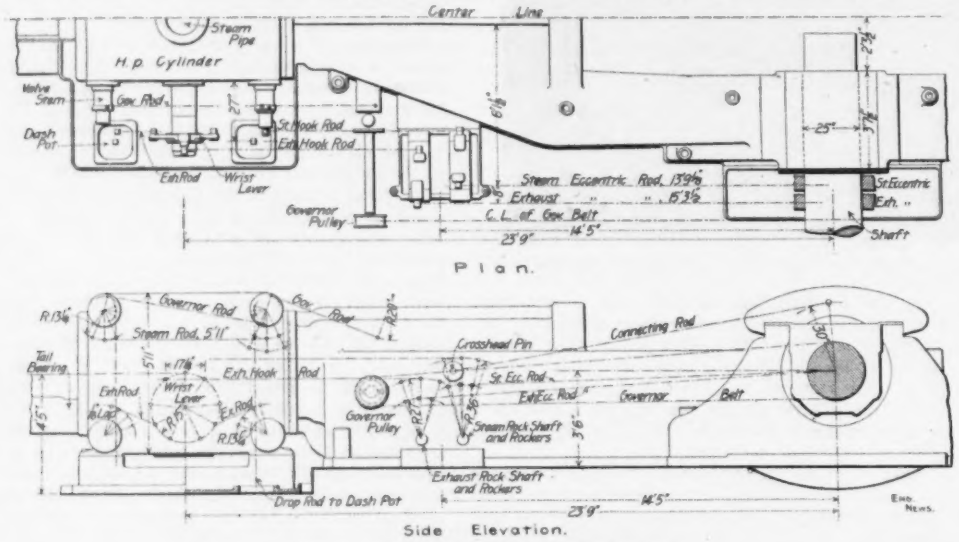


FIG. 9. HIGH-PRESSURE VALVE GEAR.

with each other, or be missing; the dimensions may disagree with each other or with the area. When discrepancies arise, the cardinal rule to follow is, effectuate the intention of the original parties. Where there is sufficient evidence to explain the conflict and point out the mistake, the line must be run upon the reformed data whether it cause the rejection of a monument or dimension. It most frequently happens, however, that no such evidence is at hand, in which event the following rules are to be applied.

Monuments are the best evidence of location of a boundary, and natural monuments are to be preferred to all other forms of description. This rule is so important that a list of cases is added containing one from nearly every state in the Union. A perusal of any one case will show the reason for the rule, and probably in addition, refer to other cases in the same state which may be looked up, as the scope of this article will not permit of stating all the authority for the rules stated:

Ayers v. Watson, 137 U. S. 584; Wright v. Wright, 34 Ala. 194; Stoll v. Beecher, 94 Cal. 1; Nichols v. Turney, 15 Conn. 101; Nivin v. Stevens, 5 Harr. (Del.) 272; Andreu v. Watkins, 26 Flo. 390; Harris v. Hull, 70 Ga. 831; Bolden v. Sherman, 110 Ill. 418; Shepherd v. Nave, 125 Ind. 226; Yocum v. Haskins, 81 Iowa 436; Bruce v. Morgan, 1 B. Mon. (Ky.) 26; Lebeau v. Bergeron, 14 La. Ann. 494; Oxton v. Groves, 68 Me. 371; Wood v. Ramsey, 71 Md. 9; Woodward v. Nims, 130 Mass. 70; Bruckner v. Lawrence, 1 Doug. (Mich.) 19; Newman v. Foster, 3 How. (Miss.) 383; Harding v. Wright, 119 Mo. 1; Johnson v. Preston, 9 Neb. 474; Cunningham v. Curtis, 57 N. H. 158; Kalbfleisch v. Oil Co., 43 N. J. L. 259; Thayer v. Finton, 108 N. Y. 394; Redmond v. Stepp, 100 N. C. 212; Hare v. Harris, 14 Ohio 529; Anderson v. McCormick, 18 Oreg. 301; Morse v. Rollins, 121 Pa. 537; Faulwood v. Graham, 1 Rich. L. (S. C.) 491; Lewis v. Oakley, 10 Heis (Tenn.) 483; Wyatt v. Foster, 79 Tex. 413; Grand Trunk Co. v. Dyer, 49 Vt. 74; Coles v. Wooding, 2 P. & H. (Virg.) 189; Teass v. St. Albans, 38 W. Va. 1; Miner v. Brader, 65 Wis. 537.

This rule, of course, applies only where the monuments were adopted as such, either by mention in the description or by reference to or use of a survey wherein they are established or used (Beckman v. Davidson, 162 Mass. 347). In such cases it is not necessary that they be seen by the grantor to bind him. No matter how exactly the survey closes or agrees with the content, if the monuments do not agree therewith, the former falls. If a line is marked on the ground in any manner, though described as straight, it must follow the breaks in the marked line if the latter is not straight. An instance of this kind frequently occurs in running up a creek; several reaches are often combined in one course; in such case the line must follow the water. This occurred in Spring v. Hewston, 52 Cal. 442.

In Esmond v. Tarbox, 7 Me. 61, a survey was made by one surveyor and marked with monuments, and a plan made by another; the deed recited the latter only. A disagreement between the two having been found, it was held that the monuments governed. In Wilson v. Bass, 6 Tenn. 110, a course called for a known point, and then crossing a river at 200 poles continued 213½ poles to its terminus. It was found that the true distance to the river was 213 poles. It was held that as the parties had agreed that it was 200 poles to the river, the line must extend 13 poles beyond the same. In Frey v. Baker, 7 Ky. L. Rep. 663, testator divided a tract into two pieces, and described the dividing line as beginning at a point at a fence, and running thence west along the fence. It was shown that the fence did not run east and west, and that testator was ignorant of that fact. It was held that the fence and not an imaginary line due west was the proper line.

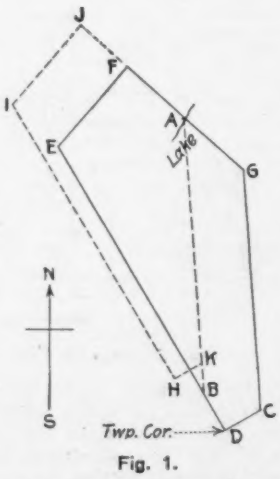


Fig. 1.

Wendell v. Jackson, 8 Wend. 183, is an early but interesting New York case. A patent had been issued for a tract described as beginning at the easterly corner of township No. 20, etc., and proceeding by various courses and distances, Fig. 1. The third course ran S. 50° E. 153 chains to the side of Schroon Lake, with content as 3,500 acres. The actual distance to the lake on the third course F G was less than one half of the distance stated. A survey for an adjacent tract, made seven days later, began at a clump of [illegible] on the side of Schroon Lake, at a corner of the preceding patent, thence followed the [illegible] around N. 50°, W. 153 chains, S. 40°, W. [illegible] chains, S. 31°, 15′, E. 330 chains to corner of town, 20, etc. It was necessary to locate the first patent to determine the title to the land northeast of E F and southeast of the line I J. The township corner used as a beginning was well marked by a stake and stones, and was at a point in a swamp difficult of access. It was argued on one side that the call for the beginning at D should be disregarded, that the second survey following the first so closely, and having been made so short a time before, should throw light on the latter, and that the first should start at A on the side of the lake, and, reversing the courses, run backwards until arriving at A. This would locate the land at A J I H K. It was held by a divided court of 14 to 5 that the beginning D being a known point, must be used and the line run to the side of the lake at A, thence to beginning, or to B. The point being, the supremacy of the call for a natural monument on the "side of a lake." This case might have been decided otherwise if many members of the court had ever had any practical experience at surveying. It is quite probable that the first survey was begun at a point H, and the line between H and D not run, owing to the difficulty of getting over a bog. The adding of an estimated distance H D was forgotten, and A K and H K calculated to make the figure close.

On the other hand, in White vs. Leming, it was held that where rejecting the call for one monument would reconcile the other parts of the deed and leave enough to identify the land, the rule was not applicable.

As between natural and artificial monuments the former will have the greatest weight. Stakes being perishable and so easily moved, are regarded as very inferior marks; in one case, Huffman v. Walker, 83 N. C. 411, the identification of the location was considered impossible. Where a monument called for is lost, its original position must be ascertained if possible. This may be done by the testimony of witnesses as to its former location, by indications on the ground, or, in the absence of these, by such methods as appear to be the nearest to certainty.

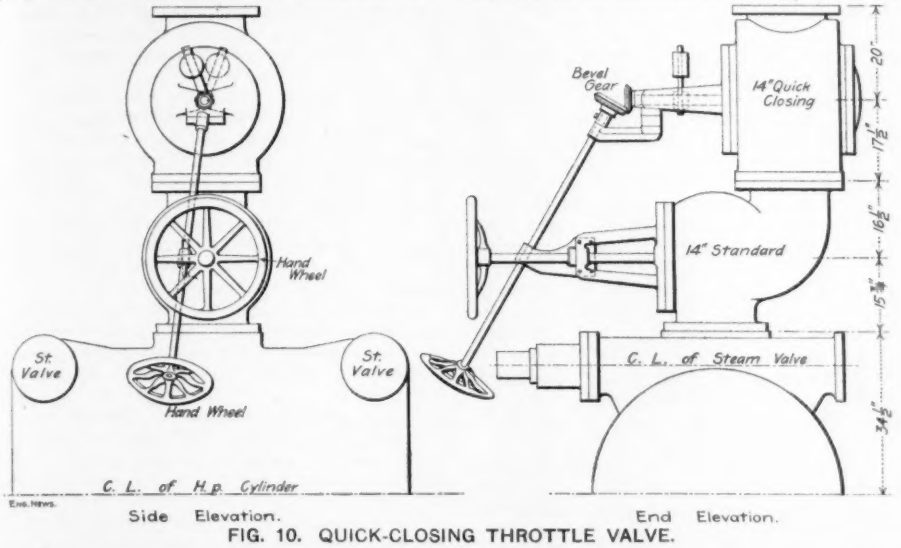
RESTORING LOST SECTION CORNERS.

In restoring lost section and quarter corners, various and conflicting rules have been stated by the land office and courts. In order to understand how to restore corners of the public land surveys, some knowledge of the method of making the original surveys should first be had. The details of the latter may be learned from several text books, or better still, from the manual of instructions issued by the government to deputy land surveyors. It may be summarized briefly as follows: In several different parts of the western country, initial points have been established from which base lines have been run towards all four points of the compass. The north and south line being straight its entire length, is referred to as the principal meridian for its section of the domain. The east and west line is called the principal base, and is likewise straight its full distance. From points on the meridian, at intervals which are multiples of six miles, lines are extended east and west and are known as standard parallels. On the base and parallels, similar multiples of six miles are laid off, and from their termini guide meridians are extended north to the adjacent parallels. The blocks thus formed are subdivided into six-mile rectangles by lines due east and west and north and south, these blocks being called townships. Sections of one mile square are next surveyed by beginning at a point on the south boundary of a township one mile west of its southeast corner, and running slightly west of north, so that each mile point shall be one mile from the east boundary of the township, all error being thrown towards the north and west. Each half mile point is marked by a "quarter corner."

In 1885 the General Land Office issued a pamphlet entitled "Restoration of Lost and Obliterated Corners." This seems to be a very good article except, perhaps, in the method it directs for find-

ing the center of a section. Where a government corner is missing, and after diligent inquiry its former position can not be ascertained, the surveyor should proceed as follows: If the point was on a base, parallel or meridian, it must be restored to a position on a line between the nearest corners on the same parallel or base, and at a distance which is a proportional part of the whole distance between the known corners. To illustrate, suppose that the intersection of a meridian with a parallel is marked, and the nearest corner south is a section corner two miles away. Three marks are missing. The distance measures 159.2 chains, and the field notes of the original survey show the distances going north to be 40 chains to first quarter corner, 40 to the section corner, 40 to the next quarter, and 39 chains to close. The excess of 0.2 must be equated all along the line so that the distances be 40.05, 40.05, 40.05 and 39.05, respectively, and corners set at these distances on a line between the two known corners.

In the same manner, points on the boundaries of a township should be set at equated distances, and on straight lines between the nearest marks on the same boundary, except in the case of the township corners when on a parallel or base. Owing to the system of completing each township by itself, its corners are not necessarily on



Side Elevation. End Elevation.

FIG. 10. QUICK-CLOSING THROTTLE VALVE.

straight lines. To relocate a township corner, not on a base or parallel, a trial line should be run between the nearest corners north and south and the distance measured and compared with the field notes. A point is then marked on the trial line at the equated distance. From this point the distances to nearest points east and west are to be measured, added and compared with the field notes and an equated distance ascertained. The point first fixed is to be moved to the east or west to suit its equated distance in that direction. The same course is to be followed in relocating section corners. Let us suppose (Fig. 2) the section corner A and quarter corners B and C are lost and we wish to relocate A. D, E, F and G are found marked.

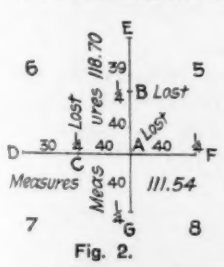


Fig. 2.

A trial line is run from E to G and the distance measured, temporary corners being marked at A and B, B being placed at 39 chains from E and A 40 chains from B, these being the distances in the original field notes. The whole length having been reported as 119 chains, is found to measure but 118.70, a deficiency of 3.30 chains. This being equated between E B, B A and A G, B must be moved N. 0.10 chains and A placed 0.20 chains north of their first temporary positions. D to F is then measured and found 111.54 chains, as compared with 110 chains on the official plat. This is an excess of 1.54 chains, and duly equated would make D C 30.42, C A and A F each 40.56. A is then to be set 40.56 chains from F and 39.90 chains from G. The quarter corners are to be set on a straight line between their section corners, hence B is to be located on a line from A to E 39.90 chains from A, and quarter corner C on a line between D A and 40.56 from A.

FINDING CENTER OF SECTION.

Two methods have been mentioned for finding the center of a section. The pamphlet above referred to suggests that it be placed at the intersection of lines run from the opposite quarter corners. Another method was to place it at a point equidistant from the quarter corners, except in the north and west tiers of sections, where it would be located as described above for section corners, using the quarters as a basis. From a legal standpoint, the following would probably be preferable:

When completely marked, the exterior of a section has eight monuments. From carelessness, these frequently disagree with the field notes. Quarters are often out of line and nearer one corner than the other. In spite of these defects, when set the marks must not be altered in position. Again, fractional subdivisions are described as "quarter sections," indicating the idea of quantity, hence a quarter section should be surveyed as one-fourth of the area of the section as physically defined. This should be done by first making a careful survey of the entire section and calculating its actual area. A point should then be fixed so that lines run from it to the quarter corners east, west and south would include exactly one-fourth of the entire calculated area. This would determine a boundary for the S. E. and S. W. ¼s. A second point on the line between the E. and W. quarters at such position, that a line drawn from it to the quarter corner north

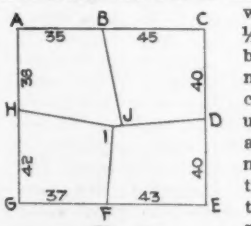


Fig. 3.

would divide the north ½ equally, should then be fixed. The section might then have two centers, as it were, but usually one point would answer the requirements. Fig. 3 will illustrate a possible condition. Suppose the field notes show a section 80 × 80, with quarter corners all 40 chains from the section corners, and a measurement shows an area of 640 acres, but the quarter corners at incorrect distances as indicated. A point I is found by calculation, so that by joining H I, F I and D I the S. E. and S. W. ¼s. are each 160 acres. A second point J is found, so that by joining B J the N. E. and N. W. ¼s. are equal to each other and the other two. The patentee of the N. W. ¼ can not complain at his irregular lines, as he receives more land than by running straight lines between the ¼ corners, as indicated by the land office circular.

FAULTY DESCRIPTION.

Where a description by course and distance does not close in itself, courses may be reversed if necessary, and clearly erroneous, as for example, A description read, "Beginning at the center of a railroad at its intersection with the B road, thence S. 20° W. along said center of said railroad 150 ft., thence N. 70° W. 50 ft. to a point, thence N. 20° E. 150 ft. to a point, thence N. 70° W. 50 ft. to beginning." Here the fourth course was plainly in error, and was read as S. 70° E., as there was evidence to show that the fourth and not the second course was erroneous. A similar error occurred in Brown et al v. Hage, 21 How. 320, where a patent read, "Beginning at a sycamore standing on the edge of the Shenandoah River, and extending thence down the said river (N. 48° W. 200 N.), etc., etc." The title to a large area depended on the retention or rejection of the words in the parenthesis, and the court said it was clear that to go down the river would not be northwesterly, it being a matter of common knowledge that the river ran in the opposite direction at this point and the words were rejected.

Where, however, a natural monument is called for by mistake, such calls will be rejected. Thus, in Land Co. v. Thompson, 83 Tex. 169, several grants began "on the side of Devil's River," under a mistaken apprehension as to its real position, no survey having been made on the ground. It was held that the surveys must be made by course and distance, recourse having been had to other established marks on the east, and the land between the true and false position of the river was excluded from the grants calling for it. The two positions are shown in the annexed sketch, Fig. 4.

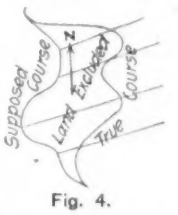


Fig. 4.

Patents calling for fractional lots along rivers do not take the land between the meander survey line and the river in Nebraska, but this state seems to differ from the others, in decisions on the point. In Jefferis v. Land Co., 134 U. S. 178, and Ayers v. Watson, the contrary was held, and United States statutes of 1796, 1800, 1805, 1820, 1832, and Sec. 2395, Rev. Stat. U. S., cited to sustain the doctrine that the land between the meander lines and river does pass with the fractional lots, even though the river be navigable. Quantity is usually subordinated to both course and distance as being the least certain element. Occasionally it may govern, however. In one case a deed called for the side of a certain highway, which at the time of the dispute was obliterated. The rear line was defined on the ground. Several positions for the lost highway were found. It was held that the one agreeing most nearly with the area described should be preferred, as none agreed with the course and distance.

Calls for adjoining surveys or tracts must be observed. This question most frequently arises in patents from state governments. In the same manner a plan or plat when referred to must be considered a part of the description. But where the plan conflicts with monuments of an actual survey on the ground, the monuments govern; unless the survey was subsequent to the plan, when, in such case, the latter controls.

The term more or less is construed as importing inexactness in all quantities to which it is annexed. It might seem ridiculous to describe a lot in feet, inches and thirty-seconds of an inch, and add to each length "more or less," but if adjacent properties or other monuments are called for, and the distances to such marks disagree with those of the description, the statement of the indefiniteness of the distances in the description becomes of some value, but, at the most, of very slight account, as the monuments would control as well without the words more or less as with them. Cases where they are of importance will seldom arise.

When course and distance disagree with each other, that will prevail which under all the circumstances and evidence appears to be the most certain.

The cases generally arise in this way: The opposite ends of two adjoining courses being agreed upon as definitely determined and located, and one course being extended to meet the other reversed to run from its opposite terminus, the point of intersection is found to disagree with the distances. The general rule is that courses prevail

over distances. Thus, in Curtiss v. Aaronson, 49 N. J. L. 68, 1886, both parties agreed until the 16th course was run. This was described as S. 24° E. 29 chains, thence S. 65° 15′ W. 151.5 chains to pine on east side of Shoal Branch. The position of this pine was not disputed, nor was the initial point of the 16th course; but by running the latter S. 24° E. to intersect the 17th course extended N. 65° 15′ E. from the pine, the 16th distance would be lengthened to 96.5 chains in lieu of 29 chains as stated. The surveyors in rerunning the entire survey where the lines were not disputed, found the courses all approximately correct, but the distances very erroneous. This fact, among others determined the court to hold that the disputed courses must be intersected and the disputed distances ignored.

On the other hand, in a somewhat similar case in Kentucky in 1821, the discrepancy between accuracy of courses as compared with distances did not appear, and the court directed the distances to be maintained, as by intersecting the courses the distances would be very greatly distorted.

Areas are regarded as the least certain of the elements of a description. So where the courses and distances do not include the same area as that stated, the latter must yield, unless the intention is clearly expressed that an area of specific quantity shall be conveyed, in which latter case the area and not the distances should control in construing the description of the land. Sanders v. Golding, 45 Iowa 463.

Plats or maps referred to in a deed are to be considered as a part of the description. The following illustrates their status: In Vance v. Fore, 24 Cal. 435, a deed referred to another deed, previously made, for a description of the premises granted, and also to a map not contemporaneous with the last deed. The description in the older deed called for no monument at the initial point, nor could any be identified with accuracy. The first course terminated at "the base of the mountain, thence running at right angles, following down the base of the mountains." The character of the country was such that witnesses might reasonably differ in their location of the lines. The map referred to showed all the natural and artificial monuments found on the ground, such as streams, buildings and roads. The descriptions as set forth in the old deed and on the map conflicted. It was held that the description shown on the plat was the most certain under the circumstances, and the least likely to be affected with mistakes, hence to be followed in making the resurvey.

There is an apparent conflict in the cases as to the relative precedence of plats, and the elements of course, distance, etc., but, as explained before, all cases must be considered from the standpoint of principle involved. The principle in this case being that that which is shown to be the most certain will prevail.

In Heaton v. Hodges, 14 Me. 66, no survey could be ascertained to have been made, and the monuments shown on the plan could not be identified; certain distances on the plan disagreed with measurements of established lines. It was held that the disputed lines were to be first scaled from the plat and the lengths so ascertained, altered in such proportion as the length of the accepted lines bore to their dimensions on the plat.

In Lampe v. Kennedy, 45 Wis. 23, several deeds were made from a plat. The courses and distances did not agree with the plat, but the latter prevailed. In the same manner, plats were held to control quantity, in 109 Ill. 46, and Hathaway v. Power, 5 Hill (N. Y.) 453.

In Beaty v. Robertson, 130 Ind. 589, it was said that where the plat and field notes of a government survey conflicted, the former showed the lines as fixed by the surveyor-general, and were those by which the land was sold, hence to be taken.

The last method of describing land is by a particular name. In earlier times, this was necessarily the most common. In such cases disputed boundaries are established by the evidence of witnesses familiar with the oldest physical location of the lines, or the admissions of interested parties. This class would include, however, description by lot and block number as per a plat. Townsite plats usually show in addition to the dimensions of the lots, stone monuments set at intersection of specified offset range lines at street corners. The monuments are frequently found to be inaccurately set, and various expedients have been adopted by later surveyors to eliminate the error. In some cases the total error of each block has been thrown in the adjacent street; in still others, the streets have been made the proper width and the error equated through the lots. Probably the best method by analogy with the decisions on lost government corners, would be to measure the distance between monuments and compare the same with the distance between the same points as shown on the plat. The difference should then be equated for every foot alike, whether street or lots.

STANDARDS OF MEASUREMENT.

Congress has never exercised its constitutional right to fix a standard of linear measurement, but an official standard having been adopted by the United States surveyors, a so-called United States standard foot has arisen, and several states have enacted statutes adopting this standard, which, in the absence of Congressional action, is lawful for the respective states so adopting them, and all standards used in contravention of such state standards are illegal in these states. This gives rise to some important questions, which will now be considered.

Where a piece of ground is conveyed and the description used is an illegal standard, that standard must be used to establish its boundaries; but if it can not be shown that the illegal standard was adopted by the parties, then the construction must be based upon the legal standard of the state. To make the case more concrete: If A owns 500 ft. front of unimproved land and sells 100 ft. from one end, this must be measured in legal standard; but if he owns one lot, described as either 20 or 100 ft., but by an illegal standard, and the further words are added, "being the same premises," etc., then he would take the same premises, or all that his grantor took in the recited conveyance, whether more or less. In other words, it is a question of intention; if both parties meant the same thing, then that is what they contracted for, or else nothing.

PROPERTY ABUTTING ON ROADS AND STREETS.

Where land is conveyed by side of a road, street or alley, the usual practice is that by implied grant, half the road is conveyed with the abutting lot. In some states the fee of the streets is in the public; in such cases the abutter stops at the side of the road. In a few isolated cases, the law has been held to be that a conveyance did not pass title to the center by implication.

Thus, in Union Cemetery v. Robinson, 5 Wh. (Pa.) 18, the general principle that a conveyance passed a fee to the center of the road was not doubted, but it was said that as in the case at bar the street described was only on paper, and unopened, and further, that the description being in feet, inches and fractions of an inch, much stress should be laid upon the minuteness of the measurements, as showing an intention to limit the conveyance to the side of the road or street. This case has very properly been overruled in the same and other states, both as respects the importance of the refinement of measurements and as to the fact that the street was unopened. The leading case on the subject being Paul v. Carver, 26 Pa. 223. The principle that a conveyance along a road carries the boundary to the center of that road has been followed in practically every state of the Union, although there have been instances where courts have been swayed by exceptional circumstances to hold that an intention was manifest to exclude the road. The words "by the side of" have been given that effect; also a grant of right of way over the strip included in the street. The following from Paul v. Carver is a forcible statement of the reason of the rule: "The rule had its origin in a regard to the nature of the grant. Where land is laid out in town lots, with streets and alleys, the owner receives full consideration for the streets and alleys in the increased value of the lots. The understanding always is that houses may be erected fronting on the streets with windows and doors, doorsteps and vaults. If a right of property in the streets might under any circumstances be exercised by the grantor, he might deprive his grantee of [illegible] means of entry into or exit from his house, and all the enjoyments of light and air, and might thereby deprive him of the means of deriving a benefit from his purchase."

Where, however, the original line between adjacent tracts existed before the road was laid out, and was not coincident with the center line of the road; then it, and not such center line, is the boundary.

Where the conveyance is along the margin of a river or other waterway, the decisions are conflicting, and no precise rule can be stated. In the majority of the states, however, a conveyance by the side of a tidal or navigable river or sea carries the fee to high-water mark, and on unnavigable rivers and ponds to their center. The side lines are projected at right angles with the thread of the stream, unless otherwise provided for in the deed.

BOUNDARIES FIXED BY AGREEMENT OR ACQUIESCENCE.

Boundaries may be fixed by agreement of the owners affected, and in such cases bind those who take from them. But if either party was led to agree by a mistake in a measurement made for the purpose, he may repudiate his agreement if he does so within a short time after discovery of the mistake. Coon v. Smith, 29 N. Y. 392. An agreement to fix a boundary where it is indefinite need not be in writing. Turner v. Baker, 64 Mo. 218.

In each state of the Union statutes exist prescribing a length of time during which various suits may be brought, and upon failure to bring such suit the cause is lost. The periods of these several "Statutes of Limitations" vary in the several states. A boundary, though erroneous, if acquiesced in by the parties for a term beyond that of the appropriate statute, becomes fixed, and as suit could not be brought to rectify it, it should be surveyed as maintained.

Estoppel is a legal principle by which one who has led another to believe that certain conditions are true, is afterwards precluded from showing such conditions are false, where the innocent party would thereby be injured. So boundaries may become fixed by estoppel. Thus, in Sheridan v. Barret, 4 Ir. 223, one led another to believe that their boundary was in a certain location, and to build a wall in a position based upon that fact. The first was compelled to adopt the boundary which he had falsely represented as being correct. See also New York Co. v. Gardner, 25 S. W. 737; Jordan v. Deaton, 23 Ark. 704.

In re-marking a boundary, we are first to satisfy ourselves that no line has been acquiesced in, agreed upon or maintained by adverse possession for the statutory period. If not, the deeds are to be examined and the line traced on the ground as originally run; if no vestiges of the latter remain, then the elements of description are to be observed in the order named, bearing in mind that that which is most certain will prevail over the less certain.

A NEW 2,300-HP. GAS ENGINE INSTALLATION FOR HIGH-PRESSURE FIRE SERVICE IN PHILADELPHIA.

A remarkable installation of gas engines is about to be made in the city of Philadelphia, Pa., in connection with improvements in its fire protection service.

There exists in Philadelphia a district bounded by Broad, Walnut and Race streets and the Delaware River, which is appropriately termed the "danger district." Within this district the loss by fire has, in the past few years, been so severe as to enforce action on the part of the insurance companies for mutual protection against heavy losses. The water supply in this district is entirely inadequate for proper fire protection, both on account of the small size of the mains and the long distance from the reservoirs. This condition prompted the city some years ago to appropriate funds for the installation of a "high-pressure fire service" which would provide a network of fire mains in this district of ample size and entirely separate from the general water system. The independence of the fire system was determined upon for the reason that the city had then in contemplation the building of an extensive water

filtration system from which filtered water would be supplied to all the city mains. After treating the water in this manner it seemed inadvisable to place the city at the unnecessary expense of using filtered water for fire purposes, and the independent system was then decided upon. In the general plans for this enterprise were included the erection of a suitable pumping station, but the funds then available for this purpose were sufficient only for the laying of mains. These are at present in operation and partially served by fire boats upon the river front. Additional appropriations have recently been made by the Bureau of Water for the erection of this pumping station and contracts for the machinery and properties are now under fulfilment.

The new station, a substantial structure, 71 × 138 ft., will be located on the Delaware River front, at the corner of Race St. and Delaware Ave., and will be used exclusively for the purpose of supplying the high-pressure fire system.

In the selection of machinery for this service it at once became apparent that a complete equipment of boilers, condensers, engines and pumps of the necessary power would introduce almost prohibitive expense not only in first cost of realty and equipment, but also in operating expenses. After giving due consideration to other available forms of power generating machinery, the gas engine was finally adopted.

The proposed plant will contain ten 280-HP., 18 × 22-in. Westinghouse, 3-cylinder, single-acting gas engines, though but seven will be at present installed. These engines will be direct-connected through suitable gearing to 1,200-gallon Deane, triplex, double-acting, piston pumps working against a maximum pressure of 300 lbs. per sq. in., and discharging into a 20-in. trunk main Two 125-HP., 13 × 14-in. Westinghouse, 3-cylinder gas engines will also form part of the equipment. These engines will be direct-connected through a friction clutch and gearing to 350-gallon Deane pumps of a type similar to the main pumps. They will also drive electric ignition generators and air compressors, which will furnish compressed air for starting the main engines. The pumps will be supplied from a 36-in. suction main taking water directly from the river and extending across Delaware Ave. to the Delaware River. Gas fuel will be obtained directly from the mains of the gas company. This source of supply is obviously not the most economical for continuous operation, but under the conditions of intermittent service, its convenience and availability far outweigh other considerations.

An examination into the extraordinary conditions of operation incident to this service points to the necessity of a prime mover which shall fulfil the following requirements:

1. Readiness for full load duty within a period of one minute from the time of alarm signal.
2. Absolute continuity of operation.
3. High economy of floor space.
4. High economy of fuel.
5. Simplicity of construction.
6. Ease and rapidity of repair.

Of the different types of power machinery available at the present time but three are at all capable of meeting the above requirements, viz.—the steam engine, the gas engine and the electric motor.

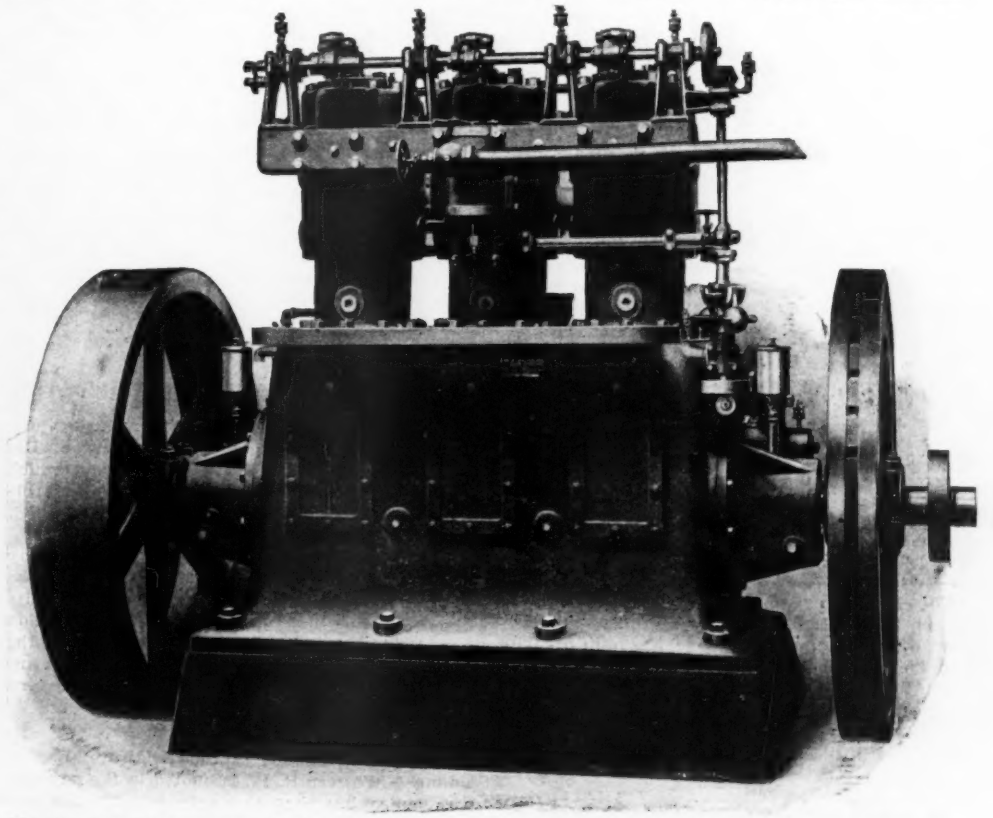
The common use of the steam pump for fire protection systems makes that system naturally the one to be first considered; but the difficulty at once met with is the boiler installation required. In the ordinary fire pump in a mill or factory, steam is supplied from the main boilers and no expense is involved in keeping the pump always ready for service. The case is entirely different in such a station as that at Philadelphia, where a special steam supply must be maintained. Very likely the pumps might not be run more than a few hours in an entire year; yet fuel would have to be burned night and day the year round to keep the boilers always ready to respond to demands. The expense for fuel and attendance which this would involve makes it extremely desirable to adopt some more economical system.

The electric motor would be in many respects an admirable method of operating such a station. The objections to it are the liability to interruption of the service from the central station, which in case of conflagration might occur just at the time when its work was most needed. In addition the motors themselves are hardly to be ranked as yet with steam or gas engines for absolute reliability of service under trying conditions.

Turning now to the gas engine, it will be apparent that its most valuable feature is its ability to start at a moment's notice without even the preliminary "warming up" which is required for steam engines of large size. This is accomplished by means of compressed air which is stored in a steel tank for this purpose. One cylinder is momentarily isolated for utilization as a compressed air motor by which the engine is given a few turns. It then enters upon regular four-cycle operation, and the starting cylinder being converted to a power cylinder, full load may be at once applied. These starting operations may be completed within half a minute after the starting signal is given, and it is immaterial whether the engine to be put in service is entirely cold or has been but recently shut down.

The ability of the gas engine to operate continuously under all conditions of load is thoroughly demonstrated by hundreds of gas engine installations in this country and abroad. A Westinghouse 65-HP., 2-cylinder gas engine installed in the works of the Consolidated Gas Co. in New York city some time ago was continuously operated for a period of 128 days. In this time the engine developed approximately 40,000 HP.-hours, making 47,650,000 revolutions, with a stoppage chargeable to the engine of 39 hours, or approximately 1¼% of the total run.

The originators of the new fire station at Philadelphia above described are Mr. Wm. C. Haddock, Director of the Department of Public Works, and Mr. Frank L. Hand, Chief of the Bureau of Water, who is in charge of the new work. The equipment will be furnished and installed by the Philadelphia firm of M. R. Muckle, Jr., & Co., representing Westinghouse, Church, Kerr & Co., Engineers, New York.



280-HP. GAS ENGINE FOR HIGH PRESSURE FIRE SERVICE PUMPING STATION, PHILADELPHIA.
The Westinghouse Machine Co., Manufacturers.

A NEW RAILWAY LINE IN SPAIN is reported by the U. S. Consular Department as being under construction. The line will run from Madrid to the seaport town Bilbao, on the north coast of Spain; communication by rail between these points is at present indirect, and the new line, 261 miles long, will reduce the distance by railway by 85 miles. The road is to be double track, of best materials, and thoroughly modern in every way. The enterprise is based on an old concession to an English mining syndicate, but the railway will be a separate undertaking, to be financed by subscription in Spain and aided by grants of land and money on the part of different cities and districts through which it is to pass. The London office of the railway company, the Sierra Company, Ltd., will be at 75 Lombard St. A map of the line, sent by the consul at Valencia, Mr. R. M. Bartleman, can be seen at the Bureau of Foreign Commerce, Washington, D. C. The railway is to be completed in five years. Consul Bartleman reports that preliminary work has already been begun.

THE RAILWAYS OF INDIA were increased 576 miles in length during the year ending Dec. 31, 1901, bringing the total mileage up to 25,373 miles. This was increased to 25,378 miles by May 1, 1902; of this length, 14,057 miles were of 5 ft. 6 ins. gage, 10,511 miles of meter gage, and 810 miles on narrower gages. These include light railways and also steam tramways running outside of municipal limits. During the year 1901, sanction was given for the construction of 715 miles, making a total of 2,126 miles sanctioned but not constructed at the end of the year. Surveys were made for about 880 miles of new line. The number of ordinary passengers carried was about 180,000,000, besides which there were 14,726,000 season tickets issued. The passenger accommodations are divided into four classes, and only 532,000 passengers traveled first-class, while 170,416,000 traveled fourth-class. The fourth-class traffic shows an enormous increase; this increase being 16,000,000 above the number for 1900. The freight traffic amounted to 44,142,000 tons, and the average haul was 160 miles per ton and 40½ miles per passenger. The equipment includes 4,020 locomotives and 80,649 passenger cars, of which 1,777 engines and 9,298 cars have automatic brakes, while 6,577 cars are fitted with the Pintsch gas-lighting system. There were 1,114 persons killed and 970 injured, of whom 94 and 298 respectively were passengers. The principal structures completed during the year were as follows: Cossye River bridge on the Bengal & Nagpur Ry., 16 spans of 100 ft.; Gokteik Viaduct on the Burma Rys., 10 spans of 120 ft., 5 of 60 ft. and 2 of 55 ft.; Teesta bridge on the Great Indian Peninsula Ry., 9 spans of 170 ft. 8 ins.; and the Garhmukhtesar bridge over the Ganges on the Oude & Rohilkand Ry., 11 spans of 200 ft.

A DIVING-BELL 137.76 ft. long and 46 ft. wide has been made by Halzmann & Co., of Frankfort-on-Main, for use in rebuilding the large dock at Wilhelmshaven. The bell weighs 350 tons, and was sent through the Kaiser Wilhelm Canal. It is to be employed in laying concrete at a depth of about 65 ft. below the water surface.

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The change from steam to electric motive power on the Mersey tunnel railway, at Liverpool, England, which is about to be made, has been brought about chiefly on account of the difficulty of ventilating the tunnel when operated by steam locomotives. Were any such tunnel to be driven at the present day, there would be no question at all as to the wisdom of operating it with electric motors from the start. In the early '80's, when the Mersey tunnel was built, however, the electric railway was not in existence. The engineers of the tunnel provided for it the most complete ventilation system, doubtless, that has ever been applied to any tunnel; but necessarily the section under the river had to be ventilated by fan stations on either side and the distance was too great to permit the tunnel to be entirely cleared of smoke between trains. The system of ventilation by a parallel heading, too, while necessary in any such tunnel, limits the capacity of the system by the high velocity required in the small heading.

Doubtless the condition of the Mersey tunnel atmosphere, and the popularity with the traveling public of the railway through it will be much bettered by the change to electric traction. It is of interest in this connection to note, however, that ventilation is needed in deep railway tunnels even when electric motive power is used. The Waterloo & City railway in London, the second of the deep tube railways built, has a villainous atmosphere. The Central London Ry., with its more frequent stations and better provision for movement of the air in the tunnel by the trains acting as pistons, was expected to be a model of perfect ventilation. Reports in the London papers state, however, that many prefer the air of the old underground railways, operated by steam locomotives, to that of the new "tuppenny tube." Recent tests have showed carbonic acid amounting to 13.8 parts in 10,000 at a station on the Central London Ry., and 27.5 parts in a crowded car on this road.

The fact seems to be that with all the admitted evil and nuisance produced by the smoke from steam locomotives, there is a certain antiseptic quality in the sulphurous gases and the soot that serves to kill odors, and perhaps prevent decomposition of organic matter in the air of the tunnel. If London experience is any guide to work elsewhere, it looks as if more attention should be paid to ventilation in railway tunnels, even though they be electrically operated.

Mistaking cause for effect is one of the most frequent errors of amateur philosophers. A good example of this, to which we are indebted to Mr. Henry Gannett, is the following:

> Some keen observer long ago detected the fact that forested regions enjoy a heavier rainfall than those not forested, and jumped to the conclusion that rainfall is produced by forests, and as a corollary that the removal of forests diminishes the rainfall. . . .
> The situation is simply that the cart has been placed before the horse. Want of rain prevents the growth of trees; want of trees does not prevent rain. This position is generally accepted among physical geographers, but the majority of the people still reverse cause and effect.

A similar set of philosophers have for years been espousing the proposition that because railways located alongside of waterways were generally prosperous, therefore the competition of a waterway is a benefit to the railway company. One of the believers in this doctrine, in a recent contribution to a contemporary, goes so far as to say: "The best thing that could happen to every railway in the United States would be to have a waterway paralleling every mile of its track." We take the liberty of doubting whether this philosopher will convert many railway owners or managers responsible for railway revenue to his way of thinking.

It is true that certain railways paralleling existing waterways are prosperous; but in every case their prosperity can be explained by causes quite apart from the existence of the waterway. Besides this, there are a good many railways which are not so happy as to be neighbors to a navigable river or canal, and yet they have achieved a high degree of prosperity.

Expenditure of public funds on waterways may or may not be desirable; but to urge it on the ground of the benefit to the railway companies savors of the ludicrous. If water competition were the inestimable boon to the railways that the philosopher above quoted imagines, railway owners and managers would have made the discovery long ago.

President Truesdale, of the Delaware, Lackawanna & Western R. R., is quoted in the newspapers as saying that the anthracite coal strike "concerns the coal mining companies and their employees and nobody else." We cannot but believe that if Mr. Truesdale is correctly quoted, he made the statement without due consideration.

In most strikes, we admit, the matters in dispute are matters in which the public generally has no concern, but when an industry becomes monopolized and a strike occurs, the situation is entirely different. The public is concerned in this coal strike, and very much concerned, too.

Several millions of people, who have nothing whatever to do with the mining of coal, have suffered loss to a greater or less extent by the stopping of the supply of anthracite coal. Had the first plan of the miners' organization been carried out and the entire production of coal in the country been stopped, the public would have been forced very promptly to face the question of public control of monopolies—whether they be monopolies of labor or capital. As it is, the anthracite famine is an object lesson which is bringing home most forcibly to men of all classes the idea that at some point in these labor struggles the public must have a right to interfere for its own protection.

The right of private property is always inferior to the public necessity. So long as anthracite mining was a competitive business, it made no difference to the public what the private mine owner did. He might close his mine or open it; he might send much or little coal to market. Competition was relied upon to protect the public, and if one mine owner did not furnish the necessary supply another would. But with the anthracite business under one control, the situation is entirely changed. Suppose the anthracite operators were to decide to close all their mines indefinitely. Would not some way be promptly found to compel the change of such a policy? The principle is already well established that when competition in an industry fails, the public has a right to interfere for its own protection and regulate the conduct of the business. Laws governing innkeepers, common carriers, purveyors of gas, water and other supplies to municipalities may be cited in support of this statement.

As to who is in the right or wrong in the present dispute—whether the coal companies ought to accede to their employees demands, or the employees should yield and return to work—we do not pretend to judge. If the coal companies can procure other competent workmen to operate the mines to their full capacity (disregarding for the moment the Pennsylvania law respecting the employment of certificated miners), then the men are in the wrong and are asking wages which free competition would not give them. If on the other hand the employers can only obtain new men by paying them higher wages than were paid before the strike, or if the old employees who return to work do so only under the stress of the hunger that accepts half a loaf as better than no bread, then the employers are the ones who should recede from their position.

The paper and discussion on the bacterial methods of sewage disposal in England, abstracted elsewhere in this issue, may well make American engineers cautious about introducing foreign processes of sewage treatment without due regard to the difference between the conditions abroad and at home. The discussion also emphasizes the need of complete, uniform and scientific records of the actual operations of American sewage purification plants. We showed in our issue of April 3, 1902, that in places of 3,000 inhabitants and upwards there were at the beginning of the current year 22 septic tanks, and 10 systems of bacteria beds connected with municipal sewerage systems, but as to the workings of most of these plants we have only the vaguest general statements, if even that, and the information given is rarely on a readily comparative basis. As Mr. Carpenter, of Pawtucket, suggests, a standard form of reports for the operation of sewage purification plants is highly desirable.

It is a pleasure to note the cordial recognition of both the American and New England Water-Works Associations shown at the recent meeting of the British Association of Water-Works Engineers. In the committee report on the standardization of cast-iron pipes reference was made to similar work by the New England association, and to a proposal from the secretary of the British association for co-operation along that and other lines. Quotations from the proceedings of both of the associations named were given in Mr. Humphrey's recent paper on electrolysis in Great Britain. It is to be hoped, and expected, that such an interchange of courtesies and ideas will be continued.

Municipal development in accordance with a systematic plan for beautifying the city is at last beginning to receive attention in one American municipality. Mr. Jacob A. Cantor, in his last quarterly report as president of the borough of Manhattan, recommends to Mayor Low the appointment of a commission of men experienced in art to devise a comprehensive plan for beautifying New York city. He says:

> I have already conferred with prominent men of these professions upon the subject, and am a firm believer in the necessity of creating such a commission. The result would be uniformity and harmony under one system, comprehensive enough to embrace all the departments, and that will be the rule instead of the exception in the construction of public improvements.

New York already has a municipal art commission, but its function is only to pass upon the artistic features of public buildings and other structures about to be erected or altered. What is needed in New York, and in other cities throughout the country, is an artistic plan for the whole city, to be followed year after year as an ideal towards which officials and citizens alike shall strive in the execution of all structures and improvements that meet the public eye.

An interesting question for mechanical engineers to settle is whether a gas engine pumping plant is or can be made as reliable for fire protection service as an "Underwriter's" steam pump. An article in this issue describes a very large gas engine pumping station in Philadelphia which is to furnish water pressure to the special system of high-pressure mains that has been laid in the "Manufacturing" district. The fitness of this plant for this work will be generally conceded; and it is likely to lead engineers to pay more attention to the gas engine for fire protection work or, indeed, for any situation where power is required only at infrequent intervals. At the same time it will have to be very clearly established that a gas engine pump can be started and kept running in an emergency with the same reliability as a steam pump before the gas engine will be generally accepted by engineers for such responsible duty.

THE BOX COLUMN.

Not so very many years ago the world of structural engineering was deep in a battle of column sections. This was about the same period when column formulas were much discussed. The struggle was one for superiority between a number of different forms of section, and it was an earnest and well-fought contest, though not a bitter one. To-day that contest is a matter of the past: the experience gained by designers, the knowledge acquired in shop and field have sought out the points of weakness in the different claims and have shown what was true merit. In due process of time certain forms of column came to be preferred for certain uses, so that they have grown to be considered standards; others were discarded and are to-day almost forgotten. Thus, the Phoenix column, one of the earliest of iron or steel columns to rise to comparative favor, is a thing of the past, while the Z-bar column has still many warm friends, and is used for many different purposes.

In general, the process of standardization has resulted in the survival of forms that are made up of standard elements, angles, plates, channel and I-beams. The Z-bar column is the exception to this rule, but it is more or less of a free-lance, having no special or definite field of application of its own, and being therefore only in a general sense a standard. As examples of real standards may be named the I-shaped column, of angles latticed or of angles and plates, a favorite for shed and mill-building work, and the latticed double-channel column, made up either of channels or of plates and angles, which is so widely used in bridges and viaducts and in general structural work. Among these standard sections of column there is one, the box column, which is more especially interesting than any of the others. It occupies a distinct field of its own, dominating this field completely and encroaching little on that of other columns. It is to the box column that we wish to draw attention at present.

In that rivalry of columns, now past, the box column was attacked at least as strongly as any other. In the face of this opposition it has made a permanent place for itself. The box column is to-day the standard in tier-building construction; it is more than that, it may be said to have made possible, to a large extent, the present development of the tier-building. In other fields this style of column never enjoyed more than slight favor, and it has lost even that. But when the high steel-frame building came in the box column also came into prominence, and the two have grown up together.

The reasons for this victory lie, of course, in the advantages possessed by the box section for this special purpose. What these are it is hardly profitable to recall, since the acceptance of the box column as an engineering standard may serve as warranty for them. Its simplicity, combined with the efficient distribution of metal it offers, are among the strongest of these advantages. It is of more value to call to mind the principal objections urged against the box column, and to inquire whether these have been met and answered, or only silenced.

The main counts against the box column were, as we remember it, two in number. The principal one of these was that the interior of the column is closed and hidden from inspection after erection, or even after manufacture. The other objection was the impracticability, where the column was used in a tier-building, of maintaining uniform dimensions of column in successive stories and thus securing uniform connections throughout the length of the column. The first of these objections applies to the column equally for whatever purpose it is used; the second applies specifically to its use in tier-buildings.

This second argument has been completely answered by experience, or possibly as much by the development of the art. In the first place, the argument has been found partly imaginary, in that there is little special virtue, or advantage either of convenience or of economy, in absolute uniformity of a series of connections. It must be remembered, too, that in most tier-building work the architectural requirements seem to be such that even reasonable regularity of the steel framing cannot be, or at least is not, attained. In the second place, experience has shown the box column more amenable than had been thought to at least partial uniformity (or, better, regularity) of detailing, so that modern designs of steel-building framework will be found to show a great advance in this respect over the practice of a decade ago.

The other objection, that the interior of a box column is hidden from inspection, retains to-day its full force. A column of that type put in place to-day will be subject to precisely the same conditions as was the box column of ten years ago. And but little, if anything, has come to the knowledge of engineers since then, as far as we are aware, that would make less valuable the ability to inspect the interior of such columns from time to time. Yet there is little heard of this objection to-day. There seems to be a tacit agreement among engineers that the argument against the closed section is not sufficiently important to militate against the most extended use of the box column in city building work. At any rate numbers of most daring structures of steel framing are erected each year which depend entirely upon the box column for their existence.

It would seem valuable, at any rate interesting, to know the opinion of the engineering world of to-day on this subject. The fact is to be noted that for purposes where other forms of column are equally satisfactory on purely structural grounds, the box column never made much headway, as was remarked above, and is to-day practically out of use. In bridgework, for instance, closed sections were regarded with disfavor from the first, especially for posts, where they could most readily be dispensed with, and this feeling has long ago spread to chord sections and even to end posts. Of course, a bridge structure is far more exposed than the framework of a high building, and for equal periods of use the requirement is more urgent that all its parts shall be readily accessible for cleaning and painting. Still, this is only a matter of relative time; and the length of life that is expected of a modern steel building goes a great ways toward equalizing the conditions.

The voices raised against the box column are not entirely still even to-day. But a few months ago an old member of the engineering profession made startling prophecies in regard to the enduring qualities of the modern high building; similar opinions are heard at times from other engineers, though rarely publicly expressed. It remains true that in the last ten years very many large and costly buildings with steel framework, the great majority of them with columns of box section, have been erected in our large cities and form the habitations of thousands of human beings. The columns were manufactured, riveted in place and forgotten, with their interior surfaces —originally covered with one or two coats of paint—in an unknown condition. What this condition is at present would be interesting information, we are sure, to all structural engineers.

It is on the basis of this line of thought that we would ask structural engineers as to their opinion about the box column to-day. Is the wide use of this type of column a real indication of the opinion of engineers as to its lasting as well as present value? Do we need occasional examination of our steel-framework structures to determine their condition? Have the objections urged against the box column years ago been answered? We should be glad to hear from our readers in answer to these and related questions.

BOOK REVIEWS.

ELECTRIC POWER TRANSMISSION.—A Practical Treatise for Practical Men. By Louis Bell, Ph. D., M. Am. Inst. E. E. Third Edition, revised and enlarged. New York: Electrical World and Engineer. Cloth; 8vo.; pp. 632. Over 300 illustrations. $3.

The first edition of this work was issued in 1897. In the present edition many additions have been made, and some of the chapters have been almost entirely rewritten in order, as the author says, to keep the volume "within hailing distance of current practice." Chapters on electrical measurements and on the present state of high voltage transmission have been added. The recent installations in California, where currents of 50,000 to 60,000 volts are transmitted for 200 miles, are discussed, and modern practice in alternating current work is described and illustrated. We can commend Dr. Bell's work as being more easy to read than any other important book on electrical engineering with which we are acquainted. It contains very little mathematical work, and such as there is is confined to simple algebraic equations. A large portion of the book is devoted to branches of the general subject of power transmission which are not entirely electrical, although a knowledge of them is necessary to a competent electrical engineer. Among these are: Engines and boilers, water wheels, hydraulic development, the organization of a power station, the commercial problem, and transmission by wire rope, hydraulic pressure, and compressed air.

STANDARD POLYPHASE APPARATUS AND SYSTEMS. —By Maurice A. Oudin, M. S., Member American Institute of Electrical Engineers. Third Edition, Revised. New York: D. Van Nostrand Co. Cloth; 5½ × 8 ins.; pp. 289. Price, $3.

The fact that a third edition of this book should be called for, when its first issue was no longer ago than 1899, indicates that it has found appreciative readers. The book is written for the users of alternating-current apparatus and is emphatically a practical manual. The civil or mechanical engineer who wishes to study long-distance transmission enough to be able to judge intelligently of the problems involved where they touch his own field of work will find this well suited to his needs. The book is by no means an elementary treatise and considerable general knowledge of electrical matters is assumed of the reader.

The application of long-distance electrical transmission has now become so extensive that every engineer ought to be familiar with at least the principal facts concerning it. Most of the treatises on alternating-current work are too profoundly mathematical for the average engineer to fathom; but the book before us is not subject to this criticism and should be correspondingly welcome.

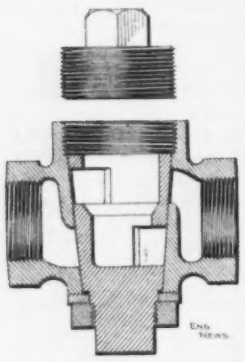
The mechanical work on the book is in general excellent, but the very heavy paper on which it is printed is a serious objection to the engineer whose library has so often to follow him in his travels.

PRACTICAL CALCULATION OF DYNAMO-ELECTRIC MACHINES.—A Manual for Electrical and Mechanical Engineers, and a Text-Book for Students of Electrical Engineering. Continuous Current Machinery. By Alfred E. Wiener, E. E., M. E., Am. Inst. E. E. Second Edition, revised and enlarged. Cloth; 8vo.; pp. 727; 390 illustrations and 125 tables. Electrical World and Engineer. $3.

The first edition of this work was published in 1897. It has now been brought up to date and much new matter has been added, including discussions of double-current generators, multi-circuit arc dynamos, secondary generators, and appendices giving dimensions and armature data of various types of modern dynamos, wiring tables, wiring data, and the causes, localization and remedies of the usual troubles occurring in dynamo-electric machines. The method of this book differs from that of the ordinary electrical text-book in giving but little space to the subjects of magnetism, induction, etc., for which the student is referred to other treatises, and in basing its treatment upon the results obtained from practice. It contains more than a hundred tables and nearly 500 formulae derived from the data and tests of over two hundred modern dynamos of American and European make. The book contains an immense amount of information, well arranged and well printed, and it should be of great service to those who are interested in the design and construction of electrical machinery for continuous currents.

A DUAL VALVE.

A valve designed to make possible, under pressure, all repairs or renewals except the renewal of the plug described below, is shown by the accompanying illustration. The case is taper-bored, with the inlet and outlet on different levels. Into the taper-bore a revolving plug, with openings corresponding to those in the case is fitted. The valve seat is inside the plug, midway between the inlet and outlet. By turning the plug half-way round the valve is as effectually closed as if the stem-valve had been turned.



A Dual Valve.

The illustration shows the stem-valve removed for repairs or renewal, and a pipe plug about to be inserted in its place, so the plug may be used as an emergency valve. In case the valve-seat becomes worn it may be repaired by inserting, in place of the pipe plug, a reseating tool the same size as the valve stem, using the valve stem wheel to turn the tool. The plug may also be used as a reducing valve by giving it a partial turn so as to partly close the openings. The valve is made by the Loetzer Valve & Manufacturing Co., Towanda, Pa.

CONCRETE TIES ON THE PERE MARQUETTE R. R.

A concrete-steel tie which has been used to some extent for experimental purposes on the Pere Marquette R. R. was described and illustrated in our issue of April 3, and a modified form of this tie is now being laid on this line at Bay City, Mich., where the railway runs through Jefferson St. for a distance of about ¾-mile, and where a permanent track construction is required. The tie as originally designed consisted of two concrete blocks connected by a pair of steel channels embedded in the concrete. In the ties now being laid at Bay City, however, the steel channels have been omitted, as the blocks abut against the concrete foundation of the street paving and therefore cannot separate. Fig. 1 is a view of Jefferson St., showing the track ready for the concrete filling and the pavement. Fig. 2 is a cross-section of the track.

The blocks are about 9 × 36 ins., 7 ins. thick, laid on a 9-in. bed of concrete, with ½-in. of cement mortar, and they are set to the exact grade by means of an engineer's level. On each concrete block is a 3-in. spiking block of white oak, the top of which is level with the top of the 6-in. concrete foundation of the street. These

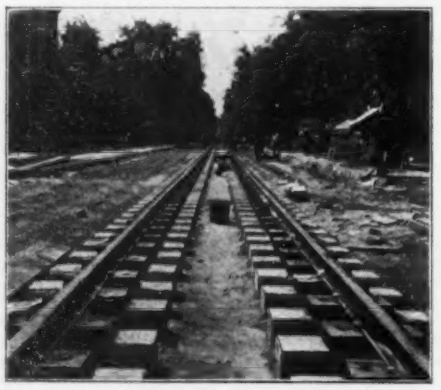


Fig. 1. Track Construction with Concrete Ties in a Paved Street at Bay City, Mich.; Pere Marquette R. R.
G. H. Kimball, Chief Engineer, Detroit, Mich.

wooden blocks are the only perishable parts of the construction. Concrete is then filled in between the ties to this level, and covered with a 1-in. cushion bed of sand for the 4-in. brick paving. The ordinary track rails are used, with concrete filling against the web, and this filling on the inner side is made wide enough to keep the bricks a sufficient distance from the rail head to form a flangeway, while the bricks next to the rail also have beveled edges to give the necessary width and flare of the flangeway. The ties are spaced 33 ins. c. to c.

For the above information we are indebted to Mr. G. H. Kimball, Chief Engineer of the Pere Marquette R. R., at Detroit, Mich., who also states that the concrete-steel ties which we illustrated and described in our issue of April 3 are now being made and will be laid in ordinary ballast at points where the traffic is heaviest and high speeds are maintained.

A MONIER CONCRETE-STEEL CEMENT STORAGE plant of rather novel construction has been built for the cement department of the Illinois Steel Co., at South Chicago, Ill., after designs by Mr. Lee Heidenreich, Civil Engineer, of Chicago, Ill. The plant consists of four circular tanks, each 25 ft. in diameter and 50 ft. high, set on the four corners of a square and close together, so that the space between the tanks in the interior of the square is also used for storage. The walls of the tanks are 7 ins. thick at the bottom and 5 ins. thick at the top, and are of concrete with a metal element of wire netting. The wire skeleton consists of a 1 × 4-in. mesh attached to and stiffened by circumferential rods spaced 4 ins. apart in elevation, and varying in size from the bottom upward from 1 in. to ⅜-in. in diameter. The sides of the tanks terminate in Z-bar caps, which carry the concrete-steel roofs, 2 ins. thick. They are mounted on columns 15 ft. above the ground, the columns consisting of steel rails embedded in concrete and resting on a foundation bed 3 ft. thick of concrete, having embedded wire netting in its bottom part. Cement is brought from the mill by a screw conveyor and discharged into an elevator leg from the top of which a screw conveyor and chutes take it into the tanks. The discharge of the tanks is at the bottom.

A SUBMARINE DRILLING AND BLASTING BOAT is being built at East Boston, by G. H. Breyman & Bros., for their coming work in Boston Harbor. The hull is 80 ft. long by 36 ft. wide, and it draws 5½ ft. of water. The bottom is 8-in. pine timber, so strengthened by bulkheads that blasting can be carried on immediately beneath it in deep water. The two anchoring spuds are 24 ins. square and 60 ft. long. After the holes are drilled, tubes are lowered and the dynamite is loaded through these tubes and forced down by a ramrod; the tube is raised with the ramrod still in place, so that the dynamite is not displaced in pulling up the tube. After firing the charge, the drills move on a track on the deck to the next set of holes, and the process is repeated until 16 holes have been drilled and blasted with one setting of the hull. The dredging vessel follows the blasting craft. The latter carries a crew of 18 men.

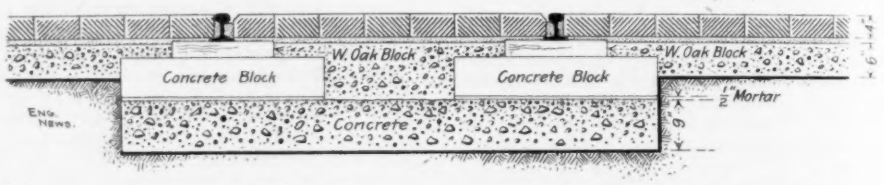


FIG. 2. CROSS-SECTION OF TRACK WITH CONCRETE BLOCK TIES.

THE WHITE STAR STEAMSHIP "CEDRIC" was launched on Aug. 21 at the Harland & Wolff ship yard at Belfast, Ireland. The "Cedric" is 700 ft. long, 75 ft. beam, 49½ ft. draft, and her carrying capacity is 18,400 tons, with accommodations for 3,000 passengers of all classes.

THE U. S. BATTLESHIP "MAINE," on her trial trip of Aug. 23, developed a mean speed of 17.96 knots; though correction for tidal effect may show greater or less speed. Her contract speed is 18 knots. The unofficial report of the builders, the Cramp Co., calls for a mean speed of 18.3 knots, without tidal allowances, with a maximum of 18.9 knots.

AN OVERLAND JOURNEY from Paris to New York via Behring Strait was completed on Aug. 25 by Harry De Windt. The time of the journey was 248 days. The explorer went from Paris to St. Petersburg, and thence to Irkutsk, Siberia, by rail. From here the journey was made with horses, reindeer and dogs through the desolate wastes of northeastern Siberia to Behring Strait, a distance of nearly 4,000 miles from Irkutsk. Mr. De Windt has attempted the journey twice before, first in 1896 and again in 1900, but each time unsuccessfully. The ostensible motive for the journey was to "demonstrate the feasibility of an all-rail route from Paris to New York," and Mr. De Windt is said to "believe [illegible]" in the scheme, which includes as a minor [illegible] tunnel under Behring Strait, but a more [illegible] explanation of his dangerous exploit is the announcement that he will appear on the lecture platform this winter.

A TELEGRAPH LINE FROM ALASKA to the United States will be completed before the end of the year, says Gen. A. W. Greely, Chief Signal Officer, U. S. A. There are now in operation about 800 miles of wire in the central and lower Yukon valley, and the Dawson-Egbert line is 450 miles long. The connection of these lines with the Valdez system, on the Yukon, will bring the lower Yukon, St. Michaels and Nome in telegraphic communication with the rest of the world.

THE FIRST HARBOR WORK IN ALASKA, under the general government, will be the improvement of the Wrangel Narrows. This is a tortuous passage 21 miles long, with shoal water and rocks dangerous to steamboat navigation. A party of government engineers, under Maj. D. W. McMorris, has been sent out to make the necessary surveys and soundings.

TESTS OF A PARSONS STEAM TURBINE driving a 1,500-K-W. alternator in the Neptune Bank power station at Newcastle-on-Tyne, England, were recently recorded in a paper before the Institution of Mechanical Engineers. The turbine was run at 1,200 r. p. m., and used steam of 196 lbs. pressure, superheated 76° F. It was connected to a condenser with 27 ins. vacuum. The mean total output of current was 1,442 K-W. and the steam consumption was 18 lbs. per K-W. hour.

AN ELECTRIC TERMINAL STATION is projected at Indianapolis, Ind., and the Indianapolis Traction & Terminal Co. has been organized for the purpose of building passenger and freight stations, with the necessary tracks and connections, for the accommodation of the interurban electric railways which center in that city. There are nine of these roads which enter or will soon enter the city, and others may be built later. The company has a capital of $500,000, and it is estimated that the entire work contemplated will cost about $3,000,000. The plans have not been definitely decided upon, but the stations are intended to be handsome structures with all conveniences for passengers, including writing and baggage rooms, lunch rooms, telegraph and telephone offices, etc. It is reported that a ten-story office building will be erected, to be used as the headquarters of the Indianapolis Street Railway Co. Mr. Hugh J. McGowan, President of this company, is interested in the new terminal company.

THE MANCHESTER SHIP CANAL OPERATIONS are summarized for the six months ending June 30, 1902, in a recent report of the directors of the canal company. During the period named the weight of toll paying merchandise which passed over the canal compared with that for the corresponding period of 1901 was as follows:

	1902.	1901.
Sea-borne traffic, tons	1,457,523	1,262,744
Barge traffic	132,840	128,405
Total	1,590,363	1,391,149

As compared with the corresponding period of 1901, the receipts showed an increase of £20,095, and as the increase in expenditure was only £1,658, the increase in profit was £18,437. The total profits in the half-year's working of the canal from all sources was £73,876, from which the directors were able to pay the interest due upon the first and second mortgage debentures amounting to £44,742, the interest due on the mortgage of surplus lands amounting to £1,000, and the rent of the new transit sheds, No. 8 dock, amounting to £3,179; and there was a balance remaining of £24,955, which has been paid to the Corporation of Manchester, on account of the interest due on the debentures they hold.

ABOUT 20,000 TONS OF LIQUID FUEL were landed at Suez in 1901, valued in the tanks at $130,285; and 16 regular Canal traders now use it. The number of vessels using the liquid fuel is increasing.

AUTOMATIC LIGHTING of street gas lanterns has been introduced tentatively in the city of Berlin, Germany, on a short length of the Schönhauserallee. The mechanism used operates electrically and extinguishes as well as lights the lamps from a distant central station through suitable circuits.

A TELEPHONE CABLE SPAN OF 3,200 FT., claimed to be the longest in the world, spans the Susquehanna River at Chiques Rock, near Columbia, Pa. It was erected by the Columbia Telephone Co. and consists of a lead-covered cable made of ten pairs of No. 19 B. & S. conductors, weighing about 880 lbs. per 1,000 ft. This is suspended to a suspension cable of steel made of seven strands of No. 12 B. W. G., weighing about 210 lbs. per 1,000 ft. The total weight of the two cables is about 1,090 lbs. The supporting poles stand 270 and 100 ft. above the river; there is a drop or sag of 122 ft. below a straight line drawn between the poles. The poles themselves are chestnut wood, each 12 ins. diameter at top; and these are anchored to two side poles. Two strands of wire previously swung across this river went down during the heavy sleet storm of last spring.

LYSOL IS A NEW DISINFECTANT discovered by Dr. [illegible]. It is produced from formalin and is known in its pure state as Lysoform. It has very marked disinfectant qualities, is not irritating to the skin, is nearly devoid of smell and it is non-poisonous. In appearance it is a clear, yellowish fluid of an oily consistency that mixes readily with water or alcohol. As a disinfectant it can be used hot or cold; and as a 3% solution it forms an excellent wash for the hands and is wholly without action on the skin.

REGULATIONS FOR MAKING AWARDS AT THE LOUISIANA PURCHASE EXPOSITION.

The special rules and regulations providing for an International Jury and governing the system of awards at the Louisiana Purchase Exposition have been made public. As these rules will doubtless interest a number of our readers, an abstract follows:

The total number of jurors in the International Jury will be about 2% of the total number of exhibitors, and each nation having 50 exhibitors will be entitled to one juror. The number of jurors for each art or industry will also be, as nearly as possible, proportional to the number of exhibitors and importance of the exhibit.

United States jurors and alternates, the latter not exceeding in number one-fourth of the jurors, will be nominated by the Chief of Departments to which the groups belong. The foreign jurors will be nominated by the foreign commissioners. All nominations must be made not less than 30 days prior to the opening of the Exposition.

Each Group Jury will select a Chairman, Vice-Chairman and Secretary, and of the two first-named officers, one must be an American citizen and the other from a foreign country represented in the Division of Exhibits. The Chief of each Department organizes and directs the Group Juries in his Department, and must be admitted to all meetings.

The work of the Group Juries will begin 30 days after the opening, and must be completed on or before 60 days after the opening of the Exposition. On the recommendation of the Chiefs of Department, and with the approval of the Director, experts may be called in special cases to report on the merits or demerits of exhibits; but these experts have no vote on the award.

Each Department Jury will be composed of the Chairman and Vice-Chairman of the Group Juries, with one member appointed by the Directory and one by the Board of Lady Managers. This Department Jury selects officers as before mentioned for the Group Juries. This Department Jury considers and reviews the reports of the Group Juries, and is to harmonize any differences that may exist between Group Juries in the matter of awards. To this work 20 days may be devoted, when the findings of the Department Juries are submitted to the Director of Exhibits, and within 10 days he shall receipt therefor and certify the same to the Superior Jury.

The Superior Jury will be made up as follows: President, the President of the Exposition; First Vice-President, the Director of Exhibits; Second Vice-President, a citizen of the United States named by the National Commission; Third and Fourth Vice-Presidents, the Commissioners General of the two foreign countries having the largest number of exhibits; and to these will be added the Chairmen and Vice-Chairmen of the Department Juries, the Chiefs of the Exhibit Departments and one person appointed by the Board of Lady Managers. The Secretary of this Superior Jury may be selected at large by the members. This Superior Jury determines finally and fully all awards, though in case of dissatisfaction the exhibitor may, within three days after official notification, file a written notice of objection with the President of the Jury, and within seven days a written statement setting forth his views as to the award. The work of the Superior Jury must be completed 130 days after the opening of the Exposition, and the formal public announcement of awards made as soon after as practicable.

The deliberations of all juries will be strictly secret; the majority rules; and all exhibits of jurors are classed as non-competitive and are not to be examined. But if the exhibit of a juror is in another group, this rule does not hold.

Whenever applicable, a decimal scale system is to be used in judging the merits of exhibits, 100 representing perfection. Exhibits receiving markings ranging from 60 to 74 will be awarded a bronze medal; from 75 to 84, a silver medal; from 85 to 94, a gold medal; from 95 to 100, the Grand Prize.

The compensation of foreign jurors will be fixed and paid by the countries they represent. United States jurors, except such as are officers and employes of the Exposition, will receive necessary and actual cost of transportation and a compensation at the rate of $7 per day for the time actually engaged in the work assigned them.

A NEW SOLAR ATTACHMENT FOR TRANSITS.

The little instrument which we illustrate herewith cannot fail to interest every engineer who has ever had occasion to determine the true meridian by solar observations, since it is a radical departure from the solar attachments for transits which are now in general use. It contains neither a telescope nor a graduated limb.

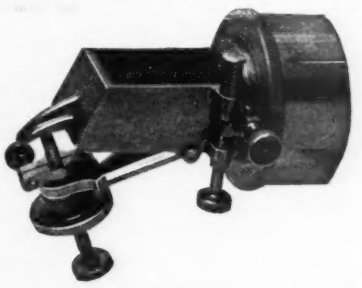


Fig. 1. The Shattuck Solar Attachment for Transits (three-fourths actual size).
Wm. Ainsworth & Son, Denver, Colo., Manufacturers.

It can be attached or detached from the transit in a moment. Its weight is only three ounces and it can be carried in the pocket when not in use. Its makers state that it equals direct observation for accuracy, and the observation can be taken in one-tenth of the time.

As seen by Fig. 1, the attachment fits over the objective end of the telescope, in place of the cap.

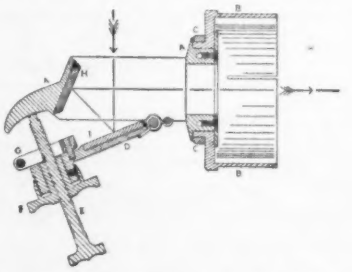


Fig. 2. Section of Shattuck Solar Attachment.

The manufacturers make the slide to fit the diameter of the telescope on the purchaser's transit without extra charge, and have devised a method of measurement by which it is unnecessary to send a transit to the factory to have the attachment fitted.

A sectional view of the attachment is shown in Fig. 2. Here the frame A A, which carries the stationary mirror H, revolves about the polar axis, coincident with the line of collimation, by means of a bearing in the cap B; and is held by two screws and a spring-washer. This frame has a clamp-ring C, which can be clamped to the cap B by the screw shown in Fig. 1. A tangent-screw and spring plunger, at the base of the frame A A, permits accurate adjustment.

The swinging arm D is pivoted to the frame A A, and is provided with a coiled spring which keeps the adjusting screw E in constant contact with the lug on the outer end of the frame A A. This swinging arm carries the movable mirror I; the adjusting screw E, for setting off the declination; the differential nut F, for setting off the hourly change in declination, and the clamp G, for clamping E, when turning F.

The light ray from the sun or star enters from above, as shown by the arrow in Fig. 2. It impinges on the mirror I, is reflected upon the mirror H, and thence through the object glass to the cross-hairs of the transit.

Besides determining the true meridian or the latitude, this attachment is useful in underground surveying, where the dip may exceed 50° or 60°, and small instrumental errors may become much exaggerated when working by ordinary methods.

The instrument is the invention of Mr. Orville F. Shattuck, a mining engineer of Denver, Colo. It is being manufactured and sold by Wm. Ainsworth & Sons, of Denver, and the manufacturers have issued a pamphlet explaining in detail the theory of the instrument, and giving full directions for determining with it the meridian and the latitude, together with necessary tables.

THE APPLICATION OF PISTON VALVES TO LOCOMOTIVES.*

By Walter M. Smith, M. Inst. M. E.†

Prior to the year 1887, piston valves had been tried experimentally in locomotive engines, but without much success, and the experiment invariably resulted in the piston valve being discarded. In 1887 the author turned his attention to the question, and endeavored to produce a satisfactory piston valve, and in the following year a compound passenger engine was built fitted with piston valves of the type shown in Fig. 1. This engine had two cylinders, 18 and 26 ins. in diameter, the length of stroke in each case being 24 ins. One valve 7 ins. in diameter was used for the high-pressure and two valves 5½ ins. for the low-pressure cylinder, the latter valves being placed side by side and actuated by one rod connected to each of the valve spindles.

The main part of the valve consisted of a center casting and two end caps mounted on the valve spindle, and retained in position between a collar and nut. The spaces between the caps and the center casting were fitted with two rings, a wide one and a narrow one. Both rings, which had been turned slightly larger than the liner into which they were to work, were cut in one place. The narrow rings were placed on the exhaust side of the valve. Both rings were retained in positions relatively to each other, and with relation to a bridge in the liner covering the gap between the rings, by a peg fixed in the center casting and engaging the rings, the gap in the wide ring coming against a solid part of the narrow ring and vice versa. The peg in the flange of the narrow ring was fitted with a tongue piece which prevented the escape of steam outwards. These rings, together with the body and ends of the valves, were made of cast iron. This metal after being at work for a short time presents a good polished surface, and gives excellent results; the wear being almost nil. The cylinders had fixed to them at either end a 2-in. spring loaded relief valve for the purpose of allowing trapped water to escape from the cylinders.

In 1891 was equipped a freight engine with cylinders and valves of the same size and form, with the exception that steam was admitted by the ends of the valves, instead of at the center of the valve, as in the previous case. As an experiment gun-metal rings were substituted for cast-iron. To get sufficient flexibility in the wide rings, the flanges formed on the same had to be made shallow. This gave very little end surface and the rings after a time became loose; and it was found necessary to make these flanges deeper, and means had to be devised to prevent the rings being too rigid. The method adopted is shown in Fig. 2. Another and better method is shown in Fig. 3. To obtain a larger bearing surface the flanges are made deeper, with pear-shaped holes cast in the same, and from the bottom of these holes to the inner surface the metal is parted by saw cuts. This arrangement gives the necessary flexibility to the rings. To prevent the passage of steam where the ring is cut, a flat piece is fitted and

*A paper read before the Institution of Mechanical Engineers of Great Britain.

†Locomotive Department, Northeastern Ry., Gateshead, England.

riveted to the flange on the exhaust side of the ring. With this form of valve it was found in practice, chiefly with spare drivers, that the relief valves did not open quick enough to allow water trapped in the cylinders to escape in time to prevent damage to the cylinders.

A considerable saving in coal was effected by this engine when compared with other engines of the same construction working with the same cut-off. But the question is not altogether one of coal-saving. The points it

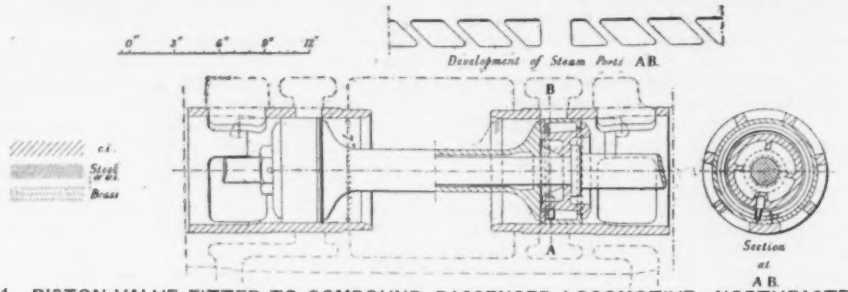


FIG. 1. PISTON VALVE FITTED TO COMPOUND PASSENGER LOCOMOTIVE; NORTHEASTERN RY., 1888.

is desired to emphasize are: The reduction of the amount of power absorbed in friction in the valves and valve motion; this is equally important, because the power so gained is utilized in producing extra work, the simplicity of the general arrangement of cylinders and valve motion also tending to reduce the cost of and the time occupied during repairs.

On the Midland Railway two engines were fitted with similar valves, and gave similar results. These facts, together with other advantages, made the subject generally of considerable interest and importance, and one worthy of further and careful study. The result of the same ending in the invention of an entirely new form of valve, illustrated in Fig. 4, and it was chiefly due to the assistance received at Derby in carrying out experiments there that this form of valve took a definite shape. As in the previous case a central casting with caps at each end is fixed on the valve spindle, between a collar and nut, and it is prevented from turning by feathers let into the spindle. In this design the broad ring is turned, and then cut to form three equal segments. The lip shown on one flange is to hold the segments in position before the valve is placed in the liner, and to limit their wear to ¼-in. Three segments and one flexible ring are fitted between each end cap and the body of the valve, and the segments are free to move outward to prevent the leakage of steam, and inward to allow trapped water to escape. Each segment is held central by a projection cast with it, which fits into a recess, formed in the end cap; sufficient space is left between the ends of the segments to allow them to collapse, so that trapped water is relieved from the cylinders. The segments, when forced inward by excessive pressure, bed on a suitable surface formed on the end caps, and when the water is discharged the segments are forced outward against the liner by the pressure of steam in the steam-chest, and so become steam-tight. To prevent the passage of steam by the ends of the segments into the exhaust chamber, the exhaust ring, made flexible by being cut, is placed between the segments and the exhaust chamber. To prevent steam passing through the cut in the ring, a tongue piece is inserted across the opening. In the steam ports bridges are formed over which the ends of the segments, and the opening in the exhaust rings, travel; by this means steam is prevented from passing in or out of the cylinders by the ends of the segments and the opening in the exhaust

Mileage and Coal Consumption for Six Months ending December, 1894.

		Total miles run.	Coal in lbs. per mile.
Slide valves	Engine No. 1621...	18,521	32.33
	" " 1620...	24,113	32.76
	" " 1624...	28,253	33.45
	" " 1623...	20,104	33.88
	" " 1627...	22,367	34.18
	" " 1626...	14,675	34.74
	" " 1622...	17,129	35.20
	" " 1631...	23,032	36.08
Average	.....	21,024	34.08
Segmental valves....	Engine No. 1639...	28,890	29.55

A saving of 13.3%.

rings. With this form of valve trapped water escapes into the steam chest, and also into the exhaust chamber.

In March, 1894, an engine was built for the Northeastern Ry. at Gateshead, and fitted with the valve last described. The following table shows a comparison between this engine and eight others of the same class, working in the same link, the difference being only in the form of the valves.

The coal used by engine No. 1639 was 2.78 lbs. less than the one next to it, and 4.53 lbs. less than the average of the other engines doing the same work.

The wear of the segments for 29,000 miles was 0.01137-in. This measurement is the average wear of four heads, and was obtained by taking the difference by weight of new and worn segments. Engine No. 1639 was one of a new type of main line express passenger engines having four wheels coupled with a leading truck, diameter of the driving wheels 7 ft. 1 in., cylinders 19 × 26 ins. The cylinders were placed inside the frames, the steam chests being outside. The original valves of this engine were replaced in November, 1899, by the type shown in Fig. 5. This pattern of valve had been used in October, 1894, in connection with the alterations made in rebuilding ten compound express engines.

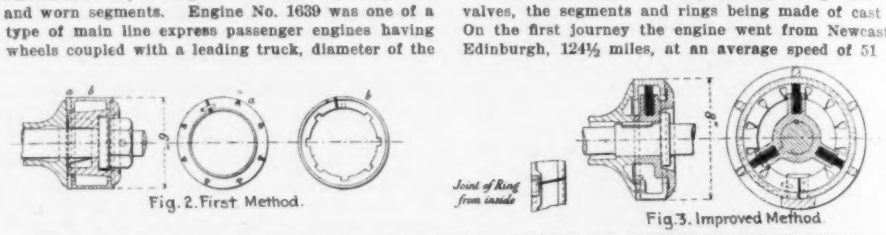
The construction of the valve is similar to that shown in Fig. 4, the difference being in the exhaust ring. After 1894, piston valves were introduced in other countries, and experiments with piston valves were being made on several railroads in America, and are now largely used there, they being applied to many of the recently constructed engines.

Thirty-five passenger engines of different classes have now been altered on the Northeastern R. R., twenty-five of them have the valves arranged below the cylinders. The valves for these engines have given comparatively very little trouble.

In 1898 engine No. 1619 was altered from a two-cylinder compound to one with three cylinders. Figs. 6 and 7 show the design of valve and liner used for the high-pressure cylinder. The chief alteration in this design is that the segments are constructed so that the section is uniform in shape, and formed so that the ring from which they are made can be turned on the inside and so fit the end caps, thus reducing the cost of machine work. Fig. 8 is a cross-section of the valve used for the low-pressure cylinders. On April 3, 1902, one of these valves broke while the engine was on its way to York with a heavy dining train. The engine having three cylinders was able to continue working its train. Slide valves do occasionally break, and cause delay to traffic; but should a segment of a circular valve break, the parts are held together and the engine is not disabled. On the return of the engine to Gateshead, the valves were examined, and it was found that the flat valves had worn down from 1 in. to ⅞-in. in thickness. These valves had to be replaced. The circular valve for the high-pressure cylinder was found to be in good condition, and was put back into its place; the average wear in all the segments was 1-16-in., the wear being in the ratio of 8 to 1. The valves were cast from the same alloy, and the mileage was 130,320; and at the present rate of wear the circular valves should show a very large increase in mileage.

Under normal conditions, the pressure on the back of the low-pressure cylinder valves would be 50 lbs. per sq. in.; that on the high-pressure valve would be a variable one, depending upon the distance the throttle was opened for the work to be done by the engine. The boiler pressure for this engine is 200 lbs. per sq. in.

NEW TYPE OF EXPRESS ENGINE.—In 1899 a new type of express passenger engine was designed and built at Gateshead. The first engine, No. 2011, started to work in August, and ran 139,543 miles up to Dec. 31, 1901, without any appreciable wear in the valves or valve motion. The valves were taken out and sent to the works for examination and were replaced by a duplicate set of valves, the segments and rings being made of cast iron. On the first journey the engine went from Newcastle to Edinburgh, 124½ miles, at an average speed of 51 miles per hour without a stop, returning to Newcastle with the "Scotchman" the same morning; and afterwards went to Leeds and back on the same day, and has since continued to perform these journeys. The average mileage for each month was 10,822. The engine was worked by a double shift of men. The total number of miles run by this engine from the time it left the shops up to June 30, 1902, was 204,475 miles.



FIGS. 2 AND 3. PACKING RINGS FOR PISTON VALVE ON FREIGHT LOCOMOTIVE; NORTHEASTERN RY., 1891.

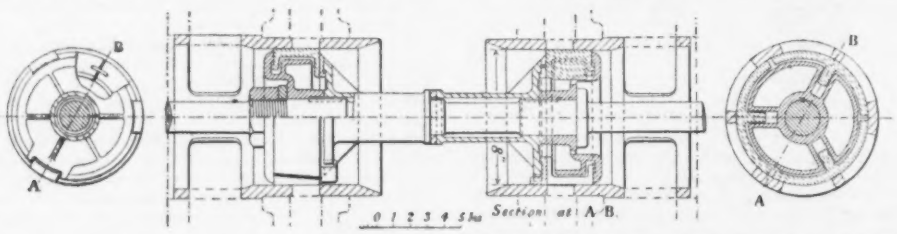


FIG. 4. PISTON VALVE FOR MIDLAND RY. LOCOMOTIVES, 1894.

To run heavy long-distance express trains with ordinary cast-iron slide valves, direct from the planing or grinding machine, would involve considerable risk.

By the end of January, 1900, ten engines of this class were at work, and they have done equally well.

At the end of May, 1902, 20 additional engines of this class were at work; these 30 engines have done better work, and cost less for repairs, than any other type of engine doing similar work. The cylinders are 19 × 26 ins.; the diameter of the driving wheels is 6 ft. 10 ins., the diameter of the truck wheels being 4 ft. The valves are 8¾ ins. in diameter, they are placed below the cylinders. The valve is shown in Figs. 6 and 7.

The total number of engines fitted with the combined form of circular and relief valve for the Northeastern Ry. is 86, and 30 are now being built.

BROKEN VALVES.—In some cases segments and exhaust rings, of the form shown in Fig. 5, have broken, but

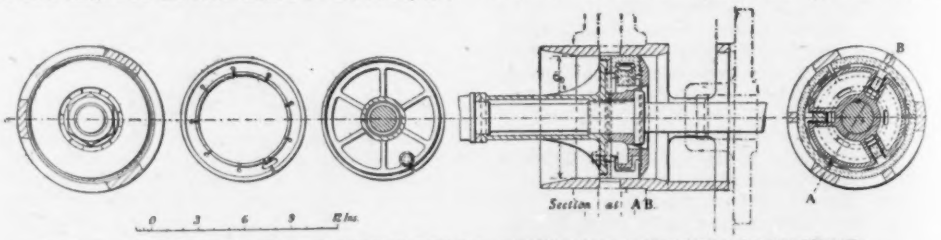


FIG. 5. PISTON VALVE FOR SINGLE-DRIVER COMPOUND EXPRESS LOCOMOTIVE; NORTHEASTERN RY., 1894.

has not been a breakage in the form shown in Fig. 6. There is no difficulty in increasing the strength of the segments and exhaust rings so as to eliminate any risk of their breaking. Any breakage that has occurred can in most cases be traced to broken pieces of the main packing ring coming in contact with the valve while passing over the steam ports. There has been a difficulty with gun metal, irrespective of the metal employed, in obtaining uniform results from what was expected to be the same mixture of metal. Valves have lasted for years

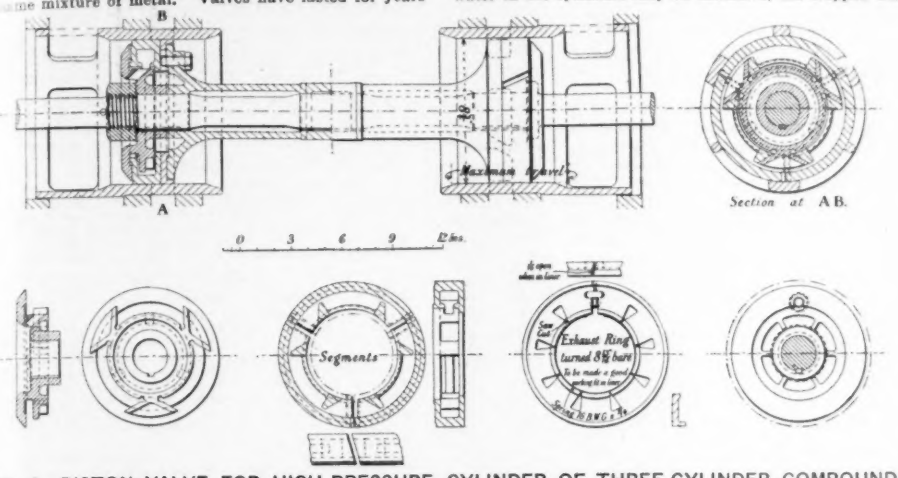


FIG. 6. PISTON VALVE FOR HIGH-PRESSURE CYLINDER OF THREE-CYLINDER COMPOUND LOCOMOTIVE; NORTHEASTERN RY., 1898.

without showing any appreciable wear or defect, while others, supposed to be of the same metal, have worn away more rapidly. What is required is a metal that will give equal results at all times without any special care being bestowed upon its manufacture. The object in employing different metals—a hard one for the liners and a softer one for the valves—was to get the liner to remain perfectly

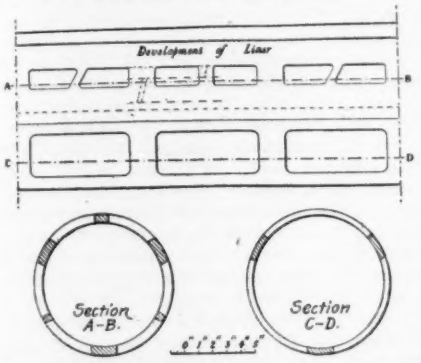


Fig. 7. Ports in Piston Valve Shown in Fig. 6.

straight and cylindrical without any signs of barrelling, the greater wear to take place in the valves, they being more readily replaced. The valves are arranged to travel over the working face of the liners for a considerable distance.

CAST-IRON VALVES.—The author has again resorted to the use of cast iron, it being possible to obtain a more uniform mixture and more uniform wear with cast iron than with bronze. The surface of cast iron becomes exceedingly hard, highly polished, and offers the minimum amount of friction and the chances of abrasion are few unless through negligence.

A piston valve for a locomotive must be tight, and to be steam tight the working surfaces must be in contact with each other. Surfaces in contact with motion means friction, and friction means wear in proportion to the amount of the friction and the nature of the metal employed. Under these conditions, it was not considered necessary, or even advisable, to make experiments with a solid piston valve. Valves with solid heads may answer for other types of engines, but not in a general way for locomotives. Experiments were made with solid exhaust rings; these did not run a couple of trips before the driver of the engine reported "valves blowing—to be examined." The valves were examined, and a number of small water grooves were turned in the ring; these, however, did not prevent leakage. The valves were again reported, and the rings had to be taken out and replaced by spring ones.

RELIEF OF TRAPPED WATER.—No piston valve for a locomotive engine is complete unless it affords a free relief to water trapped in the cylinders, and such relief must be ample and instantaneous, so as to prevent fracture to one or more important and expensive parts.

The relief of water trapped in the cylinders with the segmental valve, owing to its collapsible properties, is practically instantaneous. When the piston is near the end of its stroke the segments cover the steam ports, and are retained in position against the liner by the pressure of the steam in the steam chest acting on their inner surface. Normally this pressure is only slightly greater than the pressure from the compression end of the cylinders acting on the outer surface of the segments, but when excessive pressure due to trapped water occurs the segments are collapsed, and an annular opening is formed between the liner and the valve through which the water escapes. With the ordinary slide valve the pressure of water in the cylinders may be excessive, the trapped water acting on the area of the steam port against the pressure of steam in the steam chest acting on the total area of the valve.

EXCESSIVE COMPRESSION.—The accompanying experimental diagrams, Fig. 9, give some idea of the excessive pressure that may be obtained by too much compression. These diagrams were taken by the author from a compound engine in April, 1887, to prove with this class of engine, as then constructed, that it was absolutely necessary to give a large inside clearance to the valves, so as to reduce the abnormal compression. It was found that the engines would not run at the speed for which they were built, nor would they haul the load intended; with a clearance of a quarter of an inch on either side inside the valve, the speed increased, because the compression was reduced. These diagrams are shown here to represent what has actually taken place between the piston and the end of the cylinder with the ordinary slide valve; and what has to be provided for when using circular valves. The engine was running at a very moderate rate of speed; in fact, it would have been impossible to have gone faster, the hammering action was terrific.

Cylindrical valves, when applied to locomotives, work under different conditions when compared with other types of engines; because it may be that the highest speed is obtained running down an incline with steam shut off.

The pumping action due to movement of the pistons is destroyed by the automatic admission of air and steam, but it sometimes happens that advantage is taken when descending inclines to fill the boiler up with water to the maximum limit. On the opening of the steam regulator, should priming take place it must be instantly and automatically relieved.

The closing and opening of the steam regulator, owing to signal checks and various other causes, adds to the number of cases that tend to induce priming.

AIR AND STEAM VALVE.—The automatic air and steam valve was designed as an adjunct to the piston valve. After the regulator is closed and the engine continues to run, the action of the pistons in the cylinders creates a vacuum in the steam chest, and the object of the steam and air valve is to destroy this vacuum. The valve is shown in Fig. 10. When the contents of the steam chest become rarified, the atmospheric pressure causes the large valve to rise, and the small valve above this is lifted from its seat and steam from the boiler is allowed to enter the steam chest. The steam thus automatically admitted lubricates the cylinders, pistons and the distributing valves, and also acts as a cushion for the piston before it reaches the end of its stroke. The diagram, Fig. 11, is taken from an engine running at 60 miles per hour.

Should the pressure in the steam chest exceed that of the atmosphere the valve automatically closes, and the connection between the boiler and the steam chest is cut off. Under similar conditions, when the ordinary slide valves are used alone, they are forced from the cylinder face by air drawn in through the exhaust pipe. This is mixed with whatever is floating in the smokebox; the cylinders become dry from want of lubrication. When the valves are placed on the top of the cylinders they chatter as they are driven from the cylinder face with each stroke of the piston. A hammering action is thus set up, the strength of the blows increasing as the valves wear, the lift of the valve becomes greater.

COST OF CYLINDERS AND VALVES.—The cost of the new form of cylinders and valves has been compared with that of the ordinary cylinders and valves, and it did not differ much, but the figures are not of any permanent value. Machines adapted for the work to be done on the ordinary class of cylinders and valves are in existence, and the price has been cut down to the lowest figure, whilst, on the other hand, no special prices or machines have yet been made to reduce the cost to the lowest possible limit in the case of the segmental valves and their cylinders.

The first cost of the segmental valve, from the nature of its construction, should be a small one. The parts afterwards to be renewed are the segments and exhaust rings. These are inexpensive; the other parts of the valve should about last the lifetime of the engine.

COMPARATIVE PRESSURE PRODUCING FRICTION: SLIDE AND SEGMENTAL VALVES.—Fig. 12 shows the variation of pressures producing friction on the slide valve and the segmental valves during their travel, cutting off at 25% of the piston stroke in the steam cylinder. The

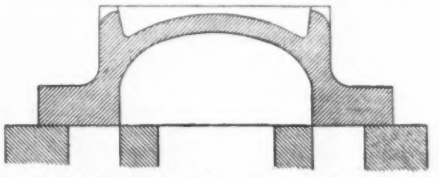


Fig. 8. Section of Slide-Valve for Low-Pressure Cylinder of Three-Cylinder Compound.

indicator diagram is divided into 26 ordinates, each of which gives the pressure producing friction at that point. The force causing friction at each point was calculated from the areas acted on for the corresponding position of the valve, and from the pressure on the opposite sides for that position. The diagram for the piston valve is similar in construction to that for the slide valve.

Prof. S. W. Robinson states in his paper:*

When the equilibrium falls between that of the cavity and of the outside of the valve, it appears that the fluid pressing on the top of the valve creeps under the edges to some extent, and the film of fluid under the valve near the cavity relieves itself by escape into the cavity. From this reasoning it would seem that for true surfaces a film of almost infinitesimal thinness is constantly creeping along between the "contact" surfaces towards the cavity; and that on the route, the pressure of the creeping fluid is continually falling, starting with nearly that of the higher pressure side of the valve, and ending at the cavity with the pressure of the latter.

When the whole lifting pressure exerted by the creeping fluid between surfaces is known, the equilibrium line can

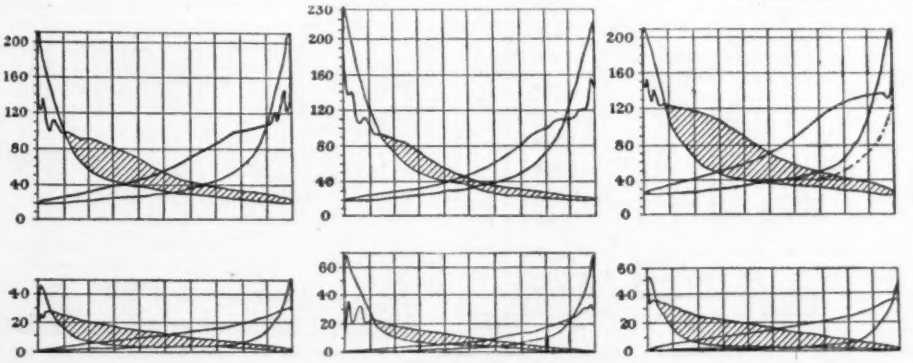


FIG. 9. INDICATOR DIAGRAMS FROM COMPOUND LOCOMOTIVE SHOWING EXCESSIVE COMPRESSION.

Boiler pressure, 135 lbs.	Cut-off, 35%.	Speed, 26 miles per hr.
" " 165 "	" 30%.	" 29 " " "
" " 160 "	" 40%.	" 21 " " "

*"Transactions of the American Society of Mechanical Engineers," 1882-83, Vol. IV., p. 151.

be located. The theoretical determination of this lifting action is the same as that for finding the force tending to throw a packing ring from its seat.

It is stated in Unwin's "Machine Design," that 3½ lbs. per sq. in. is sufficient to prevent steam passing between surfaces. In preparing the diagram a film of steam is assumed to be acting between the surfaces in contact of valve and seat. Had no film been assumed the pressure per sq. in. of surfaces in contact would be 320 lbs. for the slide valve, and 137 lbs. for the segmental valve, with

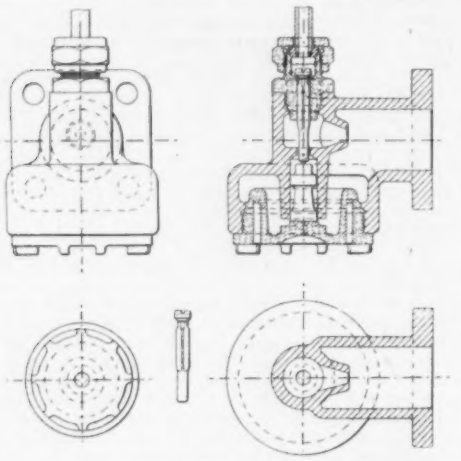


Fig. 10. Automatic Valve for Preventing Vacuum in Cylinder when Running with Closed Throttle.

steam at 130 lbs. in the steam chest. Even at this low pressure—the pressure is reduced by wire-drawing at the throttle—the pressure per sq. in. would be too high for sliding surfaces. In the case of slide blocks, well lubricated, the pressure per sq. in. should never exceed 120 lbs.

If it is assumed that a film of steam exists under all portions of the valve in contact at 126 lbs. per sq. in., and that 4 lbs. is sufficient to prevent leakage under edges of valves from steam chest to exhaust cavity, then in the case of the slide valve with 130 lbs. average downward pressure on the back of valve we have 28,300 lbs. with an average relieving pressure due to 126 lbs. film on surfaces in contact, to pressure in steam ports acting on the under side of lap of valve, and to 4 lbs. exhaust pressure acting on cavity of valve 12,334 lbs. The difference is 15,966 lbs. as the total downward pressure producing friction, and the maximum bearing area of face of valve is 78.2 sq. ins.

$$\frac{\text{Total pressure producing friction } 15{,}966}{\text{Area of surfaces in contact } 78.2} = 204 \text{ lbs. pr. sq. in.}$$

$$\text{Pressure per sq. in. producing friction} \begin{cases} \text{Slide valve} \ldots\ldots\ldots \dfrac{204 \text{ lbs.}}{40.8''} = 5.1 : 1 \\ \text{Segmental valve} \ldots\ldots \end{cases}$$

When the total pressure producing friction, and the coefficient of friction are known, a diagram worked out by a similar method will give a comparison of the power absorbed by the valves.

The following is a comparison from actual observation, which bears out that already given, so far as the comparison goes.

Slide valve: Wear $^{21}/_{32}$-in. for 78,837 miles
Segmental valve: Wear ⅛-in. for 121,600 miles.
Wear of slide valve per 100,000 miles, $^{25}/_{32}$-in.
Wear of segmental valve per 100,000 miles, $^{3}/_{32}$-in.
In proportion of about 8 to 1.

As the friction on the valve is reduced, so is the wear and tear of the valve and valve motion, and so long as the valve motion remains true the engine will continue to give good results; not only in connection with the load it will draw, but also in connection with the coal it consumes.

On the distribution of steam to the cylinders much depends. The cost of repairs, and the time an engine requires to be laid idle during repairs, are items that require to be considered in designing an engine; for the length of time the engine will run before it requires to be repaired, and the time it runs between repairs, or in reducing the cost of and the time required for repairs, the more economical will the engine turn out to be. More mileage will be run and more money earned in a given

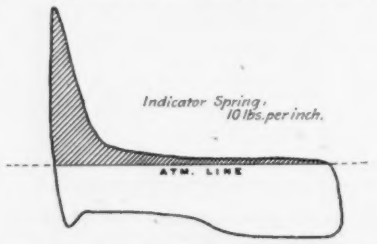


Fig. 11. Indicator Diagram from Express Engine Running 60 Miles per Hour with Closed Throttle Showing Action of Valve, Fig. 10.
(One-half scale.)

time. When segmental valves are used, as a rule, the valve motion is simply taken down, cleaned and put back into its place.

Such things as a breakdown of valve gear or heating of eccentric straps are unknown.

SLIDE VALVES AND BALANCED SLIDE VALVES.—Mr. A. E. Seaton, "Marine Engineering," p. 247, says:

No system of relieving frames, or plates has yet been tried which has given entire satisfaction; some indeed produce more resistance than they have been designed to relieve, and the best cannot be depended on for any very long period when exposed to the temperature of high-pressure steam.

The author can, from long experience, corroborate the above. A great many years ago, when on the Great Eastern Ry., most types of balanced valves were tried without success.

Recently slide valves have been observed which have actually seized on the valve face, and in some instances the edges of the valves have been bent 3-16-in. Great

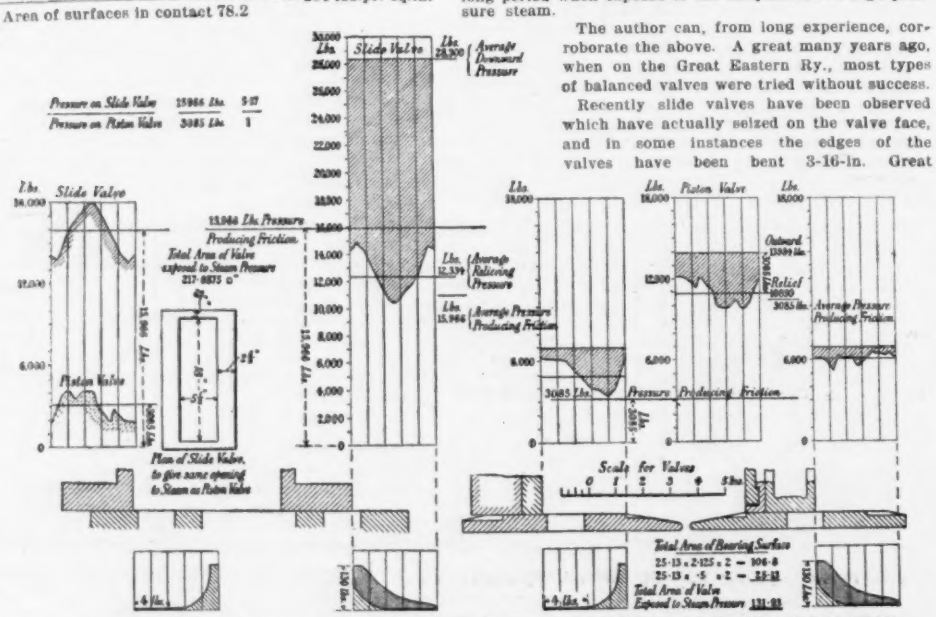

Slide Valve
Average Downward Pressure
Pressure on Slide Valve 15966 Lbs. 5·27
Pressure on Piston Valve 3085 Lbs. 1
Slide Valve
13,966 Lbs. Pressure Producing Friction.
Total Area of Valve exposed to Steam Pressure 217·8875 □"
Average Relieving Pressure
Average Pressure Producing Friction.
Piston Valve
Plan of Slide Valve, to give same opening to Steam as Piston Valve
Piston Valve
Outward 13,000 lbs.
Relief 10,000
3085 lbs.
Average Pressure Producing Friction.
Pressure Producing Friction.
Scale for Values
Total Area of Bearing Surface
25·13 x 2·125 x 2 — 106·8
25·13 x ·5 x 2 — 25·13
Total Area of Valve Exposed to Steam Pressure 131·93

FIG. 12. DIAGRAMS SHOWING RELATIVE PRESSURES PRODUCING FRICTION ON PISTON VALVES AND ON SLIDE VALVES, WITH 130 LBS. PRESSURE IN STEAM CHEST.

In contrast and dealing with the segmental valve in a similar manner, the average total outward pressure on inside of valve is 13,984 lbs., and the average relieving pressure is 10,899 lbs. The difference between the two sums is 3,085 lbs. as the total pressure producing friction, and the maximum bearing area 75.4 lbs. per sq. in.; so that

$$\frac{\text{Total pressure producing friction } 3{,}085}{\text{Area of surface in contact } 75.4} = 40.8 \text{ lbs. per sq. in.}$$

trouble was experienced in getting the valve motion to run any distance without heating. Balanced valves were put in, but to keep them steam tight the holes in the back of the valves had to be plugged up, thus destroying the attempt to balance the valve.

The author has to express his indebtedness to Mr. Wilson Worsdell, Chief Mechanical Engineer of the North-eastern Ry. Co., for the opportunity afforded him in preparing and recording the information contained in this paper.

PROPOSED STANDARDIZATION OF WATER-WORKS FITTINGS IN GREAT BRITAIN.

At the meeting of the British Association of Water-Works Engineers, in July, 1902, Mr. S. Lloyd read a paper on the "Standardization of Water Fittings." After reviewing at some length the history of water fittings as applied to domestic water service, and discussing the reasons for standardization, he names the fittings which he would have included in his scheme for standardization and the advantages that might be expected if the plan were adopted, as follows.

It is evident that in standardizing such articles as water fittings certain general principles and rules would have to be observed, but there should be a reasonable elasticity as to details to suit different conditions, and to allow of the introduction of improvements in construction. Care should also be taken to avoid hampering the trade in such a way as would tend to restrict it, or, on the other hand, to foster monopolies, one great object of the movement being to give the public the benefit of an open market. The fittings which it is suggested should be dealt with at first are: (1) connection between mains and service; (2) stopcocks; (3) draw taps for cold and hot water, including basin and sink taps; (4) cisterns and valves for closets and urinals; (5) fittings for automatic supply—such as automatic flushing cisterns and ball valves; (6) fire hydrants and road-watering posts or standpipes; and (7) hydrants. The standard might, the author thinks, prescribe the size, weight, thread, and finish of cocks, valves and hydrants, but in regard to automatic flushing cisterns the rules would have to be of a rather more general character, such designs as have been found by experience to lead to waste being specifically excluded, but the regulations otherwise restricted to such conditions as are essential to the proper working of the apparatus.

The advantages of standardization may be summed up as follows: To the water-works engineer it would give relief from a difficult and thankless addition to duties which are often quite heavy enough, and would avoid much needless waste of water; to the public it would give the opportunity of buying reliable fittings in an open market, and the certainty of always obtaining the standard article at the lowest rate without delay; to the manufacturer it would give greatly increased facilities for production and distribution at a reduced cost, resulting from having to work only one set of patterns, and from being able to keep much larger stocks of standard goods.

In the extended discussion which followed Mr. Lloyd's paper most of the speakers were at least in favor of the general principles laid down by the author, but some doubts as to the practicability of the plan were expressed, and also some fears lest standardization would prevent improvements. Most of the objections, however, were due to conservatism or misunderstanding. Some of the speakers thought the water authorities, whether public or private, should establish fittings departments. The municipality of Sheffield carries on a large and profitable plumbing business, and besides standardizing the design of the fittings it has adjusted the composition of the metal to resist the attacks of the exceptionally soft water which it supplies. This care, combined with "the introduction of regulations," is credited with having reduced the per capita consumption of water from 45 to 30 gallons since 1870. At Hull a testing department has been established and every fitting must be tested and stamped before it is used. The standard there was one of excellence, rather than size. At Torquay, of 3,591 leaks from fittings on consumers' services, 1,247 were from ballcocks and 615 from valves.

A NEW LOCOMOTIVE FUEL ECONOMIZER AND SMOKE CONSUMER.

At the last annual convention of the American Railway Master Mechanics' Association, Mr. A. M. Waitt, Superintendent of Motive Power and Rolling Stock, New York Central & Hudson River R. R., in his presidential address referred in terms of praise to a device for securing the smokeless combustion of coal on locomotives which had been tested for some months previously on a number of the locomotives under his charge. So successful had the device shown itself, he stated, that it was being specified by him for all new passenger equipment. Mr. Waitt, in a recent letter to this journal, reaffirms his original statement by saying: "I cannot speak too highly of the work this device has done. We are ordering about ten sets per month to apply to old passenger engines."

The attempt to secure a practical and efficient smoke consumer for locomotives has so often been made with small success, and the importance of a practicable device of this sort is so great, that the remarks of Mr. Waitt have attracted wide attention. In view of this fact, we describe the new smoke consumer and fuel economizer in the succeeding paragraphs.

The construction of the new smoke consumer and the manner of applying it to the locomotive are shown by Figs. 1 to 4. Briefly described, a brick arch is built projecting from the rear wall of the firebox above the fire doors. The location of this arch is shown at A B in Fig. 1 and at A B in Fig. 2. The arch is supported by studs imbedded in the side sheets, as indicated on the drawings, and these studs should be about 1 × 1½ in. with ⅞-in. taper, and screwed to the side sheets. Above the brick arch a series of holes is drilled through both sheets of the rear water leg, as shown at E E in Figs. 1 and 2. These holes are 3½ ins. in diameter, and, according to instructions, should be arranged in a line extending horizontally across the boiler head and as close to the side sheets and to each other as practicable. Through the holes are inserted short tubes, as shown at D, Fig. 3, and through the tubes are inserted other tubes or nozzles which project into the firebox nearly to the forward edge of the brick arch. The construction of these nozzles and the manner of attaching them in place are shown at F in Fig. 3.

Across the boiler head, directly back of the holes, is carried a blower pipe, taking steam from the boiler, as indicated by Fig. 4. This blower pipe is tapped at each hole by a short nozzle, which extends into the tube F, Fig. 3. Fig. 3 shows the construction of this blower nozzle. Back of the blower pipe and holes a sheet-iron hood, shown at G, Figs. 2 and 4, is attached to the boiler head.

The operation of the construction which has been described is as follows: The gases from the fire on the grates must, on their way to the tubes, pass through the opening between the regular brick arch and the special arch which has been described, as shown by the arrow in Fig. 2. Here they meet the stream of air and steam from the blower nozzles. The air from the cab passes down between the hood and the boiler head, where it is heated to about 150° F. It then passes through the heating tubes F, Figs. 2 and 3, which, because they project into the firebox, are very hot, and is there further heated to from 1,100° F. to 1,500° F. The theory is, of course, that the gases rising from the bed of fuel in the grates are kept very hot by having their escape confined to the narrow opening between the brick arches, and that at the moment of their escape through this opening they receive the necessary hot air to complete their combustion. Ordinarily, the blower nozzles are not operated except when the throttle is closed; when the engine is working the draft is sufficient to draw in the air necessary for the combustion of the gases. The steam nozzles, in other words, ensure a supply of air through the heating tubes when the engine is not working.

As will be seen, the construction and operation of the device is very simple. In regard to the success of the results secured from its use, we have the general statements of Mr. Waitt, which have already been quoted, and also the evidence of a test made on locomotive No. 943 on the Hudson Division of the New York Central & Hudson River R. R. This engine was run by the same engineer and fireman and drew the same trains before and after the application of the device. The results of the tests as furnished us by the manufacturers of the consumer are given in the accompanying table.

A subsequent test made under the direction of one of the company's road foremen of engines, and which, perhaps, more nearly approached the conditions of ordinary practice, gave the following figures:

Ordinary Fire Door.

Date.	No. of cars.	Lbs. of coal—Consumed.	Lbs. of coal—Per car-mile
Nov. 4	9	13,940	10.47
Nov. 6	11	17,250	11.67
Nov. 7	13	19,310	10.07
Total	33	50,500	*10.74
Perfection Fuel Economizer.			
Oct. 31	9	13,400	10.05
Nov. 1	12	15,650	8.75
Nov. 2	12	16,150	9.05
Total	33	45,200	*9.28

*Average.
Difference in amount of coal consumed, 5,300 lbs.
A saving of 14%.

The smoke consumer described can be applied to any locomotive. In the illustrations it is shown attached to a locomotive with a single fire door, but it can be applied as well to engines having two fire doors. The cost of application, as stated

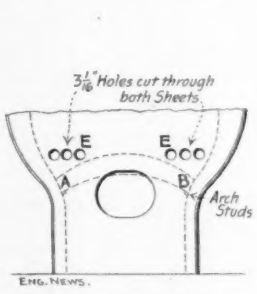


Fig. 1. Elevation Showing Location of Rear Arch and Air Supply Holes.

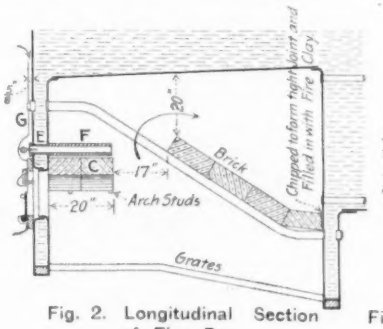


Fig. 2. Longitudinal Section of Fire Box.

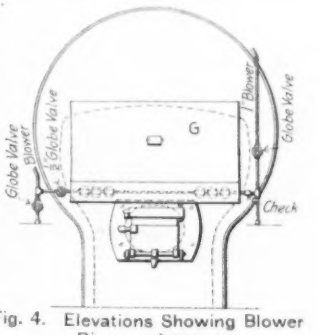


Fig. 4. Elevations Showing Blower Pipes and Hood.

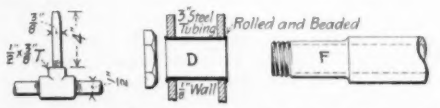


Fig. 3. Details of Heating Tubes and Steam Nozzles.

to us by Mr. A. M. Waitt, is only $30 or $35, not counting the cost of the device.

Regarding these figures, Mr. Waitt says: "These figures were obtained when we made and applied the device at our own shop on old engines, and included some labor in connection with the fire door. I believe it would be safe to say that the cost of application is under $25; this was the arbitrary figure set by the Locomotive Company in connection with the application of this device. Probably on future orders, after they get experience with it, this figure will be reduced."

Among the indirect advantages which are claimed from its use are: Reduction of the work of the fireman, a decrease in the amount of sparks thrown from the stack, decreased fouling of the tubes and a decrease in the number of leaky tubes. The consumer is manufactured and sold by the Coffin-Megeath Supply Co., of Franklin, Pa., to whom we are indebted for the information from which this description has been prepared.

Table Showing Results of Tests of Smoke Consumers on Hudson Division, New York Central & Hudson River R. R.

Ordinary Fire Door.

Date.	No. of cars.	Lbs. of coal.—Consumed.	Lbs. of coal.—Per car-mile.
Oct. 5	14½	25,530	12.31
Oct. 7	12½	22,980	12.90
Oct. 8	11½	21,980	13.31
Oct. 9	13	21,990	11.83
Oct. 10	12½	22,510	12.59
Oct. 11	12	20,300	11.13
Oct. 12	13	21,480	11.55
Total	89	156,770	*12.23
Perfection Fuel Economizer and Smoke Consumer.			
Oct. 19	16	20,080	8.71
Oct. 14	13	14,845	7.99
Oct. 15	12½	15,940	8.91
Oct. 16	12½	18,400	10.22
Oct. 17	12½	17,370	9.70
Oct. 18	11½	19,500	11.86
Oct. 20	12	18,880	11.0
Total	90	125,015	*9.77

*Average.
Difference in amount of coal used, 15 tons and 1,755 lbs. A saving of about 20% (actual 20.3%). By ½-car is meant 1 car hauled half the distance.

THE PRESENT STATUS OF THE SEWAGE DISPOSAL PROBLEM IN ENGLAND.

Among the American engineers and chemists who are following the progress of sewage disposal in England, few, if any, are keeping in closer touch with current practice in the newer methods of treatment than Prof. Leonard P. Kinnicutt, of the Worcester Polytechnic Institute, Worcester, Mass. Professor Kinnicutt is also an investigator of American theory and practice, as is shown by the recent able report which he made jointly with Mr. Harrison P. Eddy on "Experiments at Worcester, Mass., on Treating Acid Iron Sewage in a Closed Septic Tank," abstracted at length in our issue of May 29, 1902. That report was far broader than its title implied, containing a review of most of the available information on the operation of septic tanks.

There has just appeared in the June number of the "Journal of the Association of Engineering Societies" a paper by Professor Kinnicutt on "The Present Status of the Sewage Problem in England," read before the Boston Society of Civil Engineers on March 19 last. An abstract of this paper is given herewith, accompanied by three of its nine illustrations, the latter being from electrotypes of the original half-tone engravings.

The aim of the paper was to review the work of the past two years on the bacterial treatment of sewage in England, thus continuing the author's earlier paper on the same general subject. The paper was divided into three parts, dealing respectively with septic tanks, contact beds, and intermittent continuous filtration.

SEPTIC TANKS.

The first division may be passed over hastily, since the subject was so fully covered in our issue of May 29. The author concludes that the septic tank equalizes the composition of the sewage; prevents, to a large degree, the clogging of filter beds; generally renders the sewage more easily

DETAILS OF THE PERFECTION FUEL ECONOMIZER AND SMOKE CONSUMER FOR LOCOMOTIVES.

Coffin-Megeath Supply Co., Franklin, Pa., Manufacturers.

acted upon by nitrifying bacteria, removes about 26% of the total solid matter in the sewage, and from 17½ to 60% of the total organic matter, as judged from the albuminoid ammonia. The author also thinks that the amount of sludge decomposed by the septic tank "has been generally overestimated," and that "it does not usually exceed 30% of the total suspended matter arrested in the tank." As to odors, he has seen many tanks in England "which gave off most offensive odors and others which gave very little odor." The cause of this variation is unknown, and whether or not a septic tank will produce bad odors cannot be predicted. Therefore he believes that for the present tanks near dwellings or frequently traveled roads should be covered.

CONTACT BEDS.

The opening remarks on contact beds were substantially as follows:

There is no question that there is to-day a greater diversity of opinion in England regarding contact beds than there was two years ago. It is generally conceded that with a few exceptions all kinds of sewage, after having undergone preliminary treatment by the septic tank process, can be purified by contact beds so as not to undergo secondary putrefaction; that the amount that can thus be purified is about 350,000 gallons per day per acre, and that in some cases the amount may run as high as 500,000 gallons per day.

The diversity of opinion is not as regards the purification of clarified sewage, but on the question, How long will contact beds treating clarified or septic tank sewage at the above rate retain their efficiency?

The chief cause of loss in capacity of contact beds are settling down of material, breaking down of material, insoluble matter entering the bed and growth of organisms.

Loss of capacity by the settling down of the filling material takes place in the first few months of use; it amounts to about one-third of the initial liquid capacity, and can be taken into account when making the beds.

Breaking down of the filling material undoubtedly

causes a loss, but if a sufficiently hard filling material is used, this loss is comparatively small.

The loss of liquid capacity from these two causes is therefore not of a serious character, being of a known amount or not increasing after the first few months. The loss that takes place during the working of the bed is caused by insoluble matter entering the bed and by the growth of organisms. If this loss cannot be prevented or controlled, it is a most serious matter; for upon the prevention or control depends the economical working of the contact process. The solid matter that is carried on to a bed depends upon the character of the sewage and the effectiveness of previous treatment. Without question, the greater part of the suspended matter must be removed, as can be done by chemical precipitation or the septic tank, before the sewage is run upon the beds. If this is done the remaining suspended matter will consist chiefly of sand and clay in a fine state of subdivision, and with acid iron sewage a part of the suspended matter will be iron sulphide. It appears from experiments made in England as though these substances could be retained in the top 3 ins. of the bed if the upper inches of the filling material are of much finer character than the rest of the bed. These upper 3 ins., when it becomes necessary, can be removed and replaced without any very great expense.

The chief and serious question, and the one about which opinions most differ, is the loss of capacity of a bed by the growth of organisms through the whole bed and the deposition in the bed of the ash or non-putrescible part of organic substances. As to the growth of organisms, it has been shown that if the material of a contact bed in active condition be examined every piece is seen to be coated over with a slimy growth, which, if removed and dried, cuts like a jelly. Under the microscope the slime is found to be chiefly composed of bacteria and zoogloea. It is on the presence of this slimy material that the action of the bed depends; the greater the amount, up to a certain limit, the greater the efficiency; if, however, this limit is overreached, the liquid capacity is greatly diminished, the bed becomes spongy and the water will not drain away.

Experiments at Manchester, England,* seem to bear out the opinion of Mr. Gilbert J. Fowler that the growth of organisms can be regulated and trouble from ash deposits prevented. Three contact beds of 1-76-acre each, received sewage at rates of from about 375,000 to 600,000 gallons per acre from March, 1900, to March, 1901, with no permanent loss of capacity.† On the other hand, Mr. Harrison, of Leeds,‡ believes the loss of liquid capacity cannot be prevented and that contact beds are impracticable for any town with sewage like that of Leeds, which contains free acid and iron salts. After citing other opinions more or less adverse to contact beds, Professor Kinnicutt states that while he believes that

> if properly worked the contact method will prove a successful way of treating clarified sewage there is no question but that it is a method which requires skilful management, and one that can only give the best results when under the direct oversight and care of a trained engineer or chemist.

CONTACT BEDS AT OLDHAM.—The author's favorable opinion of contact beds "is no doubt influenced" by the experience of Oldham, England, a city located near Manchester, and having a combined sewerage system. In 1897, the city decided to substitute contact beds for chemical treatment, and in October, 1901, 2,000,000 gallons of sewage was being treated on an area of 4½ acres (see foot note). A detritus tank, fitted with a revolving dredger and two sets of screens and rakes, removes rags, sticks and mineral matter. From the detritus tanks the sewage passes to twelve settling tanks, 128 × 36 × 6 ft. 1½ ins., each holding about 175,000 gallons. The tank effluent, or part of it, goes to 17 contact beds, 150 × 90 ft. in area, and 21 to 36 ins. in depth. The beds have natural clay bottoms and 3 × 9-in. plank sides. In each bed are two rows of 12-in. tile drains, laid joint to joint, covered with clinkers about the size of a man's fist. The main filtering material is screened hard cinder, ¼-in. and over in size. The average cost of the beds was about $3,500 per acre. Although the beds "do not receive septic, but only clarified sewage," yet Mr. A. S. Wylie, Manager and Chemist of the Oldham works, wrote Professor Kinnicutt that four of the beds, constantly at work since 1897, show no serious signs of clogging, and the effluent conforms to the Mersey and Irwell Standard (one grain per Imperial gallon, or 1.43 parts per 100,000 of oxygen absorbed in 24 hours.—Ed.*).

As the result of septic tank and contact bed experiments begun in 1900, Mr. Wylie states:

> That with a proper arrangement of grit and screening chambers, septic tanks and storm water beds I would be willing to guarantee a non-putrefactive filtrate at the rate of 500,000 gallons per acre per day from first contact beds, and at the rate of 1,000,000 gallons, at least, from second contact beds.

THE NEW CONTACT BEDS AT MANCHESTER.—The construction of 60 contact beds, each about one-half acre in area, and averaging 3 ft. 5 ins. in depth, is in progress at Manchester, and some of the beds are already in use. The bottoms of the beds, the walls and the carriers, are of concrete. The underdrains are channels sunk in the concrete bottom, 12 ins. inside, 10 ins. deep, covered with perforated tiles. They converge at one side of the bed, and are 18 ft. apart at the other side. The main filtering material is hard, coarse cinder, the upper 3 ins. having passed ¼-in. screens and the balance having been retained on screens of that mesh. Filling and emptying the beds is controlled from the pumping station by electrical apparatus. The estimated cost of these beds is about $17,500 an acre.

INTERMITTENT CONTINUOUS FILTRATION.

Probably less is known, in this country, of the so-called intermittent continuous filtration than of either the septic tanks or contact filters. On this account what Professor Kinnicutt said on that method will be given with but few omissions:

> There is little doubt but the final purification of sewage is due to an oxidizing action brought about by bacteria, which require oxygen for their existence; and the main feature of all the methods for the final purification is to furnish sufficient oxygen to cause the greatest amount possible of bacterial action.
>
> The advocates of continuous intermittent filtration methods claim that contact beds and the American intermittent filtration beds do not fulfil this requirement. They say that before the sewage is applied to the bed, the bed, having been draining for some hours, does contain a large amount of air, and that it is at that time, and at that time only, that the bacteria are doing the maximum amount of work, i. e., changing the nitrogen of the organic matter in the sewage that still moistens the filtering material into nitric nitrogen. When the sewage is applied the air is expelled, and during the time the bed remains full the bacteria cannot obtain a supply of oxygen, and their work is reduced to a minimum; that at this time no nitrogen is changed into nitric nitrogen, and that the nitric nitrogen that appears in the effluent is only the nitrogen that was changed to nitric nitrogen when the bed was empty. Further, that the bacteria being cut off entirely from air during two or three hours, become enfeebled and only partially recover their activity during the time the bed is empty.
>
> There is more or less truth in these statements, and certainly at the present time in England the one question you are sure to be asked is, "What is your opinion on continuous intermittent filtration?"
>
> I believe a greater amount of sewage can be treated by continuous filtration than by intermittent filtration or contact beds; yet I am still to be convinced that any of the methods I have seen are of wide applicability or could be used to advantage except where the question of area was one of greatest importance.
>
> The first experiments on continuous filtration were those of Lowcock in 1892 and the late Colonel Waring in 1894. In the Lowcock experiments the attempt was made to purify crude sewage by forcing air into the gravel or broken stone filter. The result was the clogging of the filter. The reason of this, though not then known, is now understood, for to liquify the solid substances in sewage, especially the nitrogenous compounds, anaerobic action is necessary, and by forcing air into crude sewage, anaerobic action is prevented. For a similar reason, i. e., that the action is mainly aerobic, is the cause why serious trouble has been experienced when crude sewage has been applied to contact beds, and that less trouble has been experienced with intermittent filtration beds is due mainly to the greater comparative area of these beds. In the Waring experiments the suspended matter was first removed and only clarified sewage was applied, air being forced up through the filter. Waring plants have been built at Wellum Grove Park, Pa.; at Homewood, a suburb of Brooklyn, N. Y.; at East Cleveland, O., and at several other places.
>
> The continuous filters that are at the present time receiving serious attention in England do not attempt to treat crude sewage, but sewage that has been acted upon by the anaerobic bacteria, or from which all solid matter has been removed by chemicals, nor do they depend for aeration on forcing air into the filter, but on [illegible] of construction and applying the partially purified sewage in thin streams or in the form of rain. Such filters are the Scott-Moncrieff, the Ducat, the Whittaker & Bryant, the Stoddard and what may be called the Salford filter.

SCOTT-MONCRIEFF FILTER.—This differs from all the others in that it consists of a number of filters placed one above the other and separated from each other by air spaces of 2 to 3 ins. The filling material of each filter consists of 6 ins. of broken coke of about 1 in. diameter. The septic tank effluent is distributed by tipping troughs or by an automatic sprinkler on the surface of the material in the top filter and passes in thin streams through the spaces between the filters. The under filters are thus kept full of oxygen by the air carried down with the sewage.

The first experimental plant was erected at Ashstead. It consisted of nine trays, each tray having an effective area of only about 1 sq. ft. and containing 7 ins. of broken coke. The sewage was first passed upwards through a small tank containing broken stones, which acted as a septic tank, and then by means of tipping troughs was run upon the top filter in a fine stream.

A plant on this principle for treating 16,000 gallons per day was erected at Caterham Barracks in 1898. The septic tank was 42 × 20 ft. and the filters were about the same size, so that the whole installation occupied only about 200 sq. yds. The purification is said to be very successful at Caterham, the final effluent, according to Dr. Rideal, when the filter is running at the rate of 350,000 gallons per acre, containing nine parts of nitrogen as nitric nitrogen.

In South Africa, the Scott-Moncrieff plants have been erected in several places, and are stated as having been very successful. It is possible that in countries where the action of the bacteria would not be interfered with by cold weather this method might be used with success. The clogging of the filling material would take place chiefly in the top filter, and this material could be removed from time to time without great expense.

DUCAT FILTER.—These filters are designed to be always of the same size—126 × 36 ft.—and to deal with a flow of 100,000 gallons per day, equal to about 1,000,000 gallons per acre. The construction is such as to allow of the freest possible contact of air to all parts of the filter. The walls are built of open drain pipes 12 ins. long and 4 ins. in diameter, inclining inward, and supported by brick or iron piers 8 ft. apart. The space enclosed is filled somewhat as follows:

There are placed on the cement floor lines of butt-jointed drain pipes, not closed at the ends, the space between the pipes and to the height of 6 ins. above being filled with clean furnace clinker. Above this are placed 18 ins. of clinker which have passed a ¼-in. mesh. On this is a layer of 3-in. drain pipes, connecting with the butt ends of the pipes of the wall of the filter. In a normal filter there are four of these sections, making the height of the filter 8 ft.

The sewage carrier is built on one of the long walls of the filter, and at every 18 ins. there are outlet pipes discharging into tipping troughs 36 ft. long, 2 ins. deep, placed 6 ins. above the filter. Each one is supposed to deliver sewage at intervals of about six minutes.

The whole filter is surrounded with a brick wall and covered with a thatched roof. There are numerous doors and air inlet pipes on the sides of the wall, and 28 ventilators in the roof for the escape of air. The very free exposure to air causes a great cooling of the sewage in cold weather, and the filter is heated by steam passed through pipes at the bottom of the filter and between the brick walls and the filter.

A Ducat filter was put in operation at Hendin, England, in 1898, but the one I studied was an experimental one erected at Leeds under the direction of Colonel Ducat. The construction was similar to the description I have given. Crude sewage was raised to the top of the filter by a Tongye pump, and after having passed through a small grit chamber and a ⅜-in. screen, was distributed on the filter by tipping troughs at the rate of 200 gallons per sq. yd.

At first the filter was not run as a continuous filter, but was either worked continuously for 10 hours and allowed to rest for 14, or worked alternately for 10 hours and then rested for 14. Later, however, it was worked continuously.

The results obtained at Leeds were not satisfactory, owing possibly to the filling material being too fine. There was a tendency for the filter to clog and for the surface to become coated by the suspended matter in the sewage. This prevented sufficient aeration and the effluents were often poor. The best results obtained showed a purification of about 90%.

The cost of construction of this filter is large, and being obliged to heat the filter adds very materially to the cost of maintenance. It does not seem, even if all that has been claimed for the process was true, that this form of filter could be of general application.

WHITTAKER & BRYANT FILTER.—This is a circular

*Annual Report River Department, City of Manchester, 1900-1, p. 61.

†See abstract of paper by Mr. Fowler, Eng. News, Sept. 19, 1901, on "The Management of Septic Tanks and Contact Beds."—Ed.

‡Jour. Soc. Chem. Industry, 1901, p. 516.

*Mr. R. A. Tatton, M. Inst. C. E., Chief Inspector of the Mersey and Irwell Joint Committee, in his report dated April, 1902, states that for the two calendar years 1900 and 1901 10 samples were above and 9 below the limit. There is no intimation in the report that only a part of the sewage is filtered. Mr. Tatton also gives the population of Oldham as 137,238, the estimated daily quantity of sewage as 5,400,000 U. S. gallons, the capacity of the 12 settling tanks as about 2,500,000 U. S. gallons, and the total area of the 17 filters as 25,281 sq. yds., or about 5¼ acres.—Ed.

of polygonal chamber about 61 ft. in diameter and 9 ft. high, containing a central air shaft. The bottom is made of cement, with a collecting drain running along one diameter, connecting with which are tile drains set herring-bone-wise. The pigeon-hole walls of the chamber and air shaft are supported on short brick columns so that there is an air space between the walls and the concrete floor. The filling material between the outside walls and the air shaft consists of coke 1½ ins. or over in diameter.

The sewage is distributed on the surface by an automatic sprinkler, into the delivery pipe of which is placed a steam pipe so that a small jet of steam can be blown into the sewage just before it is distributed on the filter. This raises the temperature of the sewage to about 70° F., which, in passing through the filter, raises the whole body of the filter to the same temperature. The heat, according to Mr. Whittaker,

not only keeps the bacteria at their fullest activity, but raises the temperature of the air in the interstices of the filter, thereby causing it to rise through the filter and fresh air to enter, rendering the filter self-ventilating and self-aerating.

The largest Whittaker-Bryant plant is at Church, near Accrington (Fig. 1), and at this place there are ten

FIG. 1 WHITTAKER & BRYANT SEWAGE FILTER, CHURCH, NEAR ACCRINGTON, ENGLAND (1900).

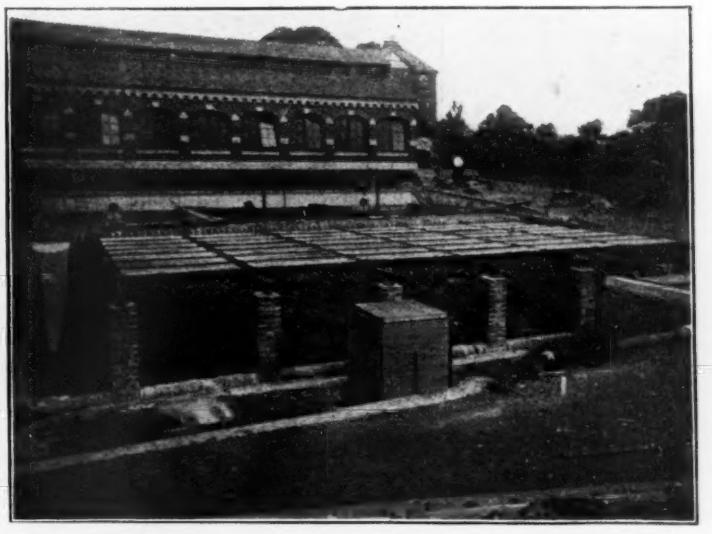


FIG. 2. STODDART SEWAGE FILTER, HORFIEL D, NEAR BRISTOL, ENGLAND (1901).

filters, each 20 yds. diameter, equaling 314.16 sq. yds. area, and four of 15 yds. diameter, equaling 146.7 sq. yds. area, the total area being 3,848 sq. yds. The sewage is distributed at the rate of 400 to 500 gallons per sq. yd. in 24 hours, which is about 2,000,000 gallons per acre. The purification is said to be good.

The experimental filter that was in use at Leeds at the time of my last visit was 24 ft. in diameter and 10 ft. high, septic tank sewage, without being heated, being sprinkled over the top of the filter.

The effluent from the filter was not a clear liquid, and contained quite a large amount of suspended matter. This suspended matter is said not to be putrescible, and owing to the large size of the individual particles, soon settles out. The amount of purification accomplished by the filter running at the rate of 1,000,000 gallons per acre was good. The effluent at Leeds, after the settling out of the suspended matter, shows a purification of 92% in albuminoid ammonia and 93% in oxygen consumed on the crude sewage, and 84% and 87%, respectively, on the septic tank effluent. The amount of nitrogen in the effluent as nitric nitrogen is from 1 to 2 parts in 100,000. More or less trouble was caused by the clogging of the surface of the filter by suspended matter and vegetable organisms. This hindered good aeration and necessitated frequent and periodic forking over of the top layers. The effluent appeared to contain so much suspended matter that it would have to be passed through a sedimentation basin before being run into the water-course.

The sprinkling arrangement, though automatic, required attention, owing to stoppage of the small holes by suspended matter. Further, in winter it would seem, on account of the openness of the filter, to be absolutely necessary to warm the sewage, and, as I have stated, Mr. Whittaker claims that better results are obtained at all times if this is done. This of course adds greatly to the expense of the process.

STODDART FILTER.—A form of continuous filter that has attracted much attention in England during the past year is the Stoddart (Fig. 2). The filter itself is made of any hard, jagged material, as coke, hard-burnt cinder, iron slag, ranging in size from 2 to 3 ins. and from which all finer material has been carefully removed. The floor of the filter is made of cement concrete, with a fall of 1 in. in 3 ft. from the center to the collecting channel, which surrounds but lies entirely outside the filter. No channels or pipes of any kind are laid within the filter or on the floor.

As no liquid collects within the filter, retaining walls are unnecessary, and the sides of the filter can be made of large pieces of the filling material with a slight batter to increase solidity. If it is considered desirable to inclose the filter, the retaining wall is placed inside the collecting channel and is built on short brick columns in order to allow the ready escape of the effluent. The three essential points in the construction of the filter, according to Mr. Stoddart, are the arrangement of the floor, the uniform grade of the filtering medium and the freedom of the latter from dust or fine particles.

The distributer invented by Mr. Stoddart is in principle very simple. It is made of zinc or galvanized iron and consists of a number of perforated gutters, 11 in each section, 2 ins. wide and 1½ ins. deep, arranged at right angles to the supply channel. The perforations are cut in diamond shape at intervals along the upper edge of the gutters. On the under surface of the gutters are a number of small points, 360 per sq. yd. The distributer rests upon the margin of the supply channel and upon suitable supports at the further end, and must be perfectly level to secure equal distribution. The clarified sewage flows from the supply channel into the gutters and over the gutters through the diamond-shaped perforations and falls from the small points in a series of drops.

A filter such as described, Mr. Stoddart claims, will successfully treat clarified sewage containing about 0.5 parts albuminoid ammonia per 100,000 parts at the rate of 500 gallons per cu. yd. per day, or in a filter 6 ft. in depth each square yard of surface will deal with 1,000 gallons, equaling 4,840,000 gallons per acre; and, further, that the more diluted the sewage is with rain-water the greater can be the rate of filtration, and that the plant at Bristol, when the sewage was diluted with storm water, has frequently run at the rate of 30 to 40 millions gallons per acre per day for several hours in succession. This, of course, would do away with all necessity for storm filters. The cost, according to Mr. Stoddart, is 35 to 40 shillings per sq. yd. 6 ft. deep (as high as $47,000 per acre.—Ed.).

Small plants have been built at Knowl and at Horfield, Bristol, and I believe at several other small places, and experimental plants are now being tried at Manchester and Leeds. I hardly know what to say of this method. I have carefully examined the plant at Knowl, Bristol, and the experimental filters at Manchester and Leeds. The filter at Bristol was running, at the time of my visit, at the rate of 5,000,000 gallons per acre; there was very little appearance of organic matter on the surface of the filter, and the filtrate was clear and without odor. The analysis of the filtrate that had been made showed that it was not putrescible. The albuminoid ammonia had been reduced from 0.5 to 0.13 parts and the nitrogen as nitric nitrogen equaled 1.48.

The experimental filters at Manchester and at Leeds have not given nearly as good results. The one at Manchester does not give a clear filtrate, and when running at the rate of 360 gallons per sq. yd. (1,800,000 gallons per acre) a number of samples were putrescible. Mr. Stoddart claims that the construction at Manchester is faulty; that on two sides the filter was surrounded by earth to the height of about 2 ft., preventing aeration. Since my visit this earth has been removed and the experiments are being continued.

Considerable difficulty must be experienced in insuring regular distribution. The plates must be kept perfectly level and all buckling prevented. Further, if the clarified sewage contains any amount of suspended matter, this will settle in the gutters in a very short time, necessitating continual cleaning of the gutters.

The same difficulty with this filter as with the Whittaker-Bryant filter must be experienced in winter, and in the winter cold of New England I should expect the filter at times to be completely coated over with ice. It is, however, on account of the very high rate at which it is claimed it can treat clarified sewage, a method that is well worth attention and study.*

THE CORBETT FILTER, SALFORD.—By far the most interesting experiment I know of on continuous intermittent filtration is the plant now nearing completion at Salford, England, built according to the plans of Mr. Joseph Corbett, Borough Engineer (Fig. 3). At this plant the sewage of a city of about 250,000 inhabitants, with a dry-weather flow of sewage of over 8,000,000 gallons, is to be treated by this comparatively new method.

The sewage is first to be treated chemically and the clarified sewage run through roughing filters filled with gravel at the rate of 4,000 gallons per sq. yd., the rate to be increased up to 16,000 in stormy weather. From the roughing filters it is to flow by gravity to the valve chambers and be delivered on the aerating bed.

This bed is 500 ft. long, 510 ft. wide and 10 ft. deep and filled with cinders passed by a ½-in. and rejected by a ⅛-in. mesh.

From the valve chambers run two delivery mains, 30 ins. in diameter. One of these is connected with seven horizontal pipes, the other with eight. These pipes run the whole length of the bed, dividing it into 16 sections, and the flow in each pipe is controlled by a valve. From each of these 15 pipes are raised vertical pipes 10 ft. apart and 10 ft. high. Each of these stand pipes is connected at right angles with 4-in. horizontal pipes which run across the bed. On the top of the bed, therefore, there is a layer of horizontal pipes 10 ft. apart. These horizontal pipes are fitted with vertical spray jets at every 5 ft., each spray pipe having two ¼-in. holes set at an angle toward each other.

The floor of the filter has a fall of 2 ft. from inlet to outlet, and is covered with tiles raised on feet sufficiently high, about 3 ins., to insure air circulation beneath the filter. The drains are underneath the 15 large horizontal pipes at the bottom of the chamber, and all discharge into a main culvert which carries the filtrate into the river.

The sewage passes from the valve chamber into one or both of the mains, and is delivered to any or all of the horizontal pipes. From these it passes up the vertical pipes into the 4-in. horizontal pipes and then into the spray pipes. There is a sufficient head to cause the liquid to spout out of the spray pipes to a height of from 5 to 8 ft., and it will then fall like rain on the surface of the filter.

The dry-weather flow upon the bed is to be about 500 gallons per sq. yd., to be increased, when necessary, to 1,000 gallons.

There is no question that the construction of this plant is costly, but it seems to me that the chances of successful treatment are greater with Mr. Corbett's plant than by any other method of continuous filtration I have seen.

*For further information regarding this filter, see the paper by Mr. Stoddart himself, abstracted in this issue.—Ed.

The plant should be in full operation this year, and the result will be very instructive, whether it is a failure or a success.

Intermittent continuous filtration is able to treat larger quantities of clarified sewage on a given area than any other bacterial process, and it has the advantage over the contact method that the accumulation of solid matter in the filter does not reduce the volume of liquid which can be treated until the amount of solid matter in the filter interferes with free passage of the liquid, which condition may be found never to occur. In conclusion, I can only say that, though believing in the principle involved in the continuous filtration of sewage which has been acted upon by anaerobic bacteria, I do not think it is as yet a method which can be considered as practical, especially on a large scale and in a climate where the winter temperature is similar to that of New England.

DISCUSSION BEFORE THE BOSTON SOCIETY OF CIVIL ENGINEERS.

The paper elicited a lengthy discussion. Mr. Leonard Metcalf, Assoc. M. Am. Soc. C. E., called attention to the fact that "English results must be interpreted from the point of view of English conditions and environments, rather than our own." In England, the sewage is more concentrated than here, rendering impossible high rates of filtration without previous treatment. The colder climate of portions of America apparently renders continuous filtration, with the spraying of sewage, impracticable, "for in our colder weather the applied sewage would soon form a solid sheet of ice upon the surface of the bed." With the Stoddart filter we should expect the drip holes in the trough distributors to clog, and the distributors to get out of alinement. The tendency to use finer materials at the top of the English filters is worthy of note as applicable to contact beds, but not to American intermittent sand filters. The most promising fields for septic tanks and contact beds appear to be in localities where suitable filtering material is expensive and a high degree of purification is not essential.

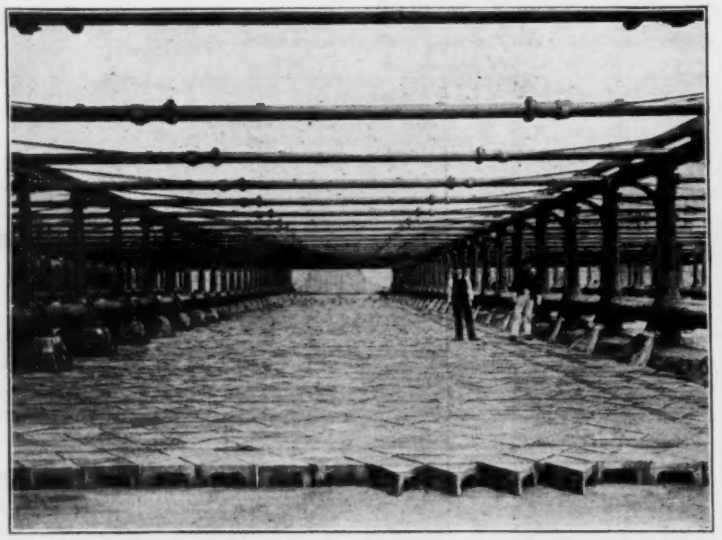


FIG. 3. CORBETT FILTER, SALFORD, ENGLAND (1901).

It is unfortunate that the progress of the science of sewage disposal bids fair to be seriously impeded by patent considerations and the possibility of legal entanglements. The writer understands that already in the case of one city, where some most valuable experiments upon the disposal of the city's sewage are being conducted, has concluded not to publish further results obtained from the septic tanks on account of the attitude and claims of certain companies controlling septic tank and contact bed patents—patents upon the validity of which the courts have, however, not yet been given an opportunity to pass.

The writer is of the opinion that the various patent claims upon the broad principle of septic tank treatment will not stand the test of the courts. On the other hand, it is probably true that certain of the mechanical appliances or devices connected with the tanks are original.

Some of the patent considerations involved have been discussed by the writer in an article upon the "Antecedents of the Septic Tank," Transactions of the American Society of Civil Engineers, Vol. XLVI., 1901.

Prof. W. T. Sedgwick thought the septic tank "will play in the future an important part in sewage disposal, especially for separate houses, institutions, sanitariums and the like," but regarding contact beds he had "always been more skeptical." He then continued:

I visited Colonel Waring's plant when it was at work in Newport, and while the theory of it was fairly good, it never seemed to me to be as good as he thought it was. His theory was this: In intermittent filtration we get only so many hours a day of work out of the bacteria, and if we could work them all day we should probably get better quantitative results. Here, it seems to me, was the fallacy, for it does not follow that if we work a man 24 hours a day we necessarily get more out of him than if we work his only 10 hours. Of course, bacteria are very different from human beings, and yet I think that it is not difficult to see how the double-contact beds may lose their liquid capacity if treated on this system because of bacterial growths. For what we want is to get the bacteria to clean up the last part of the sewage, which is always the poorest part and for them the poorest food. Now, if they have plenty of the richer, better part they will often not take the trouble to feed upon the poorer part. They are likely to devour only the better food and let the poorer go. These statements are not based upon analogy merely, but upon well-known facts in the nutrition of the lower micro-organisms, and I do not think that when bacteria are well fed for 24 hours, or any large part of it, they are likely to oxidize efficiently the last (i. e., the most refractory) portions of the sewage, which are poor food for bacteria; and I do think that they are very likely to multiply enormously upon the abundant richer portions, perhaps passing into that jelly stage which is a part of their life history, settling down, as it were, and, like stall-fed oxen, growing fat and doing very little work. I throw this idea out merely as a suggestion; but I would be almost willing to predict that in those contact filters which lost their liquid capacity and became stopped up, the sewage was less purified—that is, was richer in food for bacteria before it went upon the filter—than was the case in those filters which remained comparatively open.

Mr. Frank A. Barbour, M. Am. Soc. C. E., said the septic tank had "apparently proved its right to exist as a means of preliminary treatment, but as to the value of contact beds, opinion is more unsettled." Experiments have shown that the action of contact beds, as generally operated, is "largely anaerobic, and that air does not enter so much between doses as with the sewage during its inflow." Intermittent dosing "in quick, short flushes" was suggested, with distributors designed to thoroughly spread the sewage. The dosing apparatus at Mansfield, O., is arranged with that end in view. The attempt should be to confine anaerobic action to the septic tank, "making all subsequent action one of oxidation and nitrification." Thorough aeration between the septic tank and the contact beds seems necessary. Whether lack of this accounts for the reduced capacity of contact beds in England the paper did not make clear.

It would seem preferable to limit "fine material to a small area around the outlets, depressing the surface" thus covered "so as to form a pool 3 ins. deep, across which the liquid would flow with a slow velocity and enter the coarse material of the bed surface beyond." This plan was adopted at Mansfield, O., and was suggested by observing that at Marion, Ia., a septic tank effluent in flowing over the ground to a stream leaves "a slight deposit near the tank," but "reaches the stream comparatively free from suspended solids." Little attention appears to be paid in England to "the advantages of greater air space and less settlement to be gained by using a material more uniform in size of particle." At both Mansfield and Lakewood, O., Mr. Barbour had used the most vitrified portion of crushed and screened cinders, varying in size from ¼ to ¾-in., costing about 85 cts. per cu. yd. in place. Half of the cost was for purchase and transportation of cinders, and half for crushing and screening. About 85% of the volume of the raw material was available for use.

Tests made by Mr. Barbour showed that high rates could be obtained from a sand filter by placing "an aerating layer of gravel and air pipes at mid-depth" in the filter.

The relatively low standards of purification accepted in England was thus commented on by Mr. Barbour:

Professor Kinnicutt has referred to the Irwell & Mersey standard, which calls for an albuminoid ammonia not exceeding 0.14 part per 100,000 and an oxygen consumed not exceeding 1.40 parts per 100,000. This is equivalent, on the basis of the albuminoid ammonia, to the liquid which would result by diluting ordinary raw sewage with six times its volume of water. In this country it is generally considered that at least 2.5 cu. ft. per day of water per 1,000 people contributing sewage, or a dilution of 40 times is necessary to prevent a nuisance in the stream.

It is evident, therefore, that one of the first requirements in order to understand the present status of sewage disposal in England is an appreciation of the quality of effluents with which authorities there are satisfied. This lower standard is the explanation of many of the systems proposed, because neither by contact beds nor continuous filters, operated at high rates, can such degrees of purification as are usually obtained from intermittent sand filters be economically obtained. Cinder filters, 5 ft. deep and properly equipped, will cost from $10,000 to $25,000 per acre, and if a high degree of purification is demanded, the necessary area will be such that the cost will, except under unusual conditions, compare unfavorably with that of sand filters.

The adoption of a lower standard of purification in a thickly settled country is natural. All streams must serve to a certain extent as carriers of waste matters, and neither legally or logically can it be expected that the water will continue to flow as it is "wont by nature." Recognizing this, it is reasonable to accept an effluent adapted to the stream conditions—not attempting the transformation of sewage to drinking water, but insuring that no nuisance will be created. In this direction lies the greatest field for the use of high-rate bacterial methods of sewage purification.

Mr. Geo. A. Carpenter agreed with the author of the paper in his opinion that the amount of sludge which a septic tank can decompose has been overestimated.* To indicate the final disposition of the solids in sewage treated by septic tanks Mr. Carpenter has prepared two tables (here combined in one) based upon an arbitrary outline suggested by Mr. Geo. W. Fuller, Assoc. M. Am. Soc. C. E. The figures for Pawtucket were obtained by actual measurement, and those for other places were computed in accordance with Professor Kinnicutt's estimate that "the amount of sludge decomposed does not usually exceed 30% of the total suspended matter arrested in the tank." The figures in the table, Mr. Carpenter says, show

the need of more detailed information than we yet possess to enable the engineer to predict the results which may be expected from the passage of a particular sewage through a septic tank.

In studying water-works operation uniform statistics have been found necessary, and the same thing must be brought about "before we can hope to obtain the fullest information and an intelligent comparison of results."

In closing the discussion, Professor Kinnicutt made the following statement regarding purification standards:

My own opinion as to the degree of purification is that it should not depend on the amount of albuminoid ammonia, the amount of oxygen consumed, the nitrogen as nitrites and nitrogen as nitrates contained in the effluent, though these data do give valuable information; but that the standard should be whether or not the effluent will undergo secondary putrefaction. This likelihood of secondary decomposition cannot be determined from the above factors, but from Scudder's incubator test. If a sewage effluent from any process gives continuously good results with the incubator test, it certainly seems to show that such an effluent cannot undergo secondary decomposition when run into a watercourse.

*See Eng. News, Feb. 27, 1902, for an extended review of Mr. Carpenter's experience at Pawtucket.

Final Disposition of Solids in Sewage Treated in Various Septic Tanks.
(Parts per 100,000.)

	Suspended solids.				Total solids in raw sewage excluding amount dissolved in septic effluent.	Solids gasified = e — (b + c + d).	Percentage distribution of solids (e) of the sewage.			
	In raw sewage. (a)	In tank effluent. (b)	Decomposed by septic tank.* (c)	Balance left as sludge. (d)	(e)	(f)	Tank effluent (b)	Sludge. (d)	Liquefied. (c)	Gasified. (e)
Exeter.....	35.00	15.40	5.88	13.72	33.90	— 1.10	45	41	17	— 0.03
Leeds.....	47.60	14.10	10.05	23.45	56.70	9.10	25	41	18	16
Manchester..	37.15	15.95	6.36	14.84	51.72	14.57	31	29	12	28
Worcester....	20.06	17.90	0.65	1.51	34.51	14.45	52	4	2	42
Pawtucket...	38.37	12.10	5.73	20.54	45.21	6.84	27	45	13	15

*Figured as 30% of a-b.